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A multiple spindle drill in a Toledo automobile factory that bores 81 holes at once in an aluminum crank case

QUANTITY PRODUCTION OF AUTOMOBILES [See page 244]

Training in Military Aviation*

The Methods of the British Schools

DURING peace aviation was such a novel proposition that most of the training took the form of flying pure and simple. Military subjects were taught to some extent on the ground, but in the air, as was only natural, the art of handling the machine, of landing it and of finding the way across country, was all that mattered. In those days bomb-dropping, photography, wireless and fighting in the air were scarcely mentioned. The school was divided up into several flights, and the training was progressive through these flights. Almost all pupils started in the Maurice Farman flight with a period of dual control instruction. They then had a spell of solo work on the Maurice Farman, including a few short cross-country flights. From that they were moved to one of the advanced flights, and were given dual control instruction either on Avros or B.E. 2's and so on, to solo on either one of these types. A particularly promising pupil usually had the opportunity of flying two or three other types of machines before he left the school. The final test was a cross-country flight, at which a height of about 3,000 feet had to be reached, and a spiral landing with engine stopped at its conclusion. Reconnaissance height in those days was considered to be 3,500 to 4,000 feet, and it was only the exceptional pupil that reached anything higher. To sum up, the art of flying was taught as well as it possibly could be, whereas the military side of aviation, as it is understood to-day, was not really included. The school was being large enough to fill the requirements of both services, a certain proportion of officers who had taken their tickets were sent direct to squadrons for training in the early stages.

On the declaration of war all available resources were sent straight into the field, and the only unit left intact so far as the army was concerned was the C.F.S., and even that was severely denuded both of instructors and of aeroplanes, which was taken to bring the service squadrons up to their fighting strength. Then came a very lean period in England, during which very few pilots were produced, for the simple reason that neither sufficient instructional aeroplanes nor instructors were available. It became necessary to formulate some sort of policy. It was obvious that if the war went on for any time we should want a great many more squadrons in the field, and the output of the C.F.S. in pilots could not possibly be sufficient for the replacement of wastage of the squadrons already in the field and the formation of the new ones. New squadrons were therefore started at all existing stations as officers and material became available, and the question arose as to whether these existing stations should be extended to take a considerably larger number of squadrons in the future, or whether new stations should be started in various parts of England. The latter policy was decided on for two reasons, First, it seemed likely that the best and most economical number of pupils—given unlimited aeroplanes—which could be trained on one aerodrome without undue delay and congestion would be about 60. The number of pupils it was thought that one reserve squadron could properly train averaged between twenty and thirty, and it was therefore considered that the ideal station should accommodate from two to three squadrons, either reserve or service. The second reason was that it seemed a pity to have all one's eggs in the same basket. The wonderful English climate varies enormously in different parts of this comparatively small country, with the result that while the weather was hopeless in London, the Midlands might be perfect; Yorkshire might be impossible while flying was in full progress in Scotland. It, therefore, seemed sound to scatter these aerodromes as much as possible. An additional advantage of this scattered disposition was that the new aerodromes would form halting places for new machines being brought down from the contractors, and that this system would also ensure so far as was possible that all parts of the new army training in England would see and have some knowledge of aviation. The disadvantages of this system were that the available talent in instructors was scattered instead of concentrated, and probably more instructors were required for a given number of pupils.

After two or three months of war the system obtained was as follows: The C.F.S. was turning out pilots who were usually absorbed in replacing casualties abroad. There were a certain number of reserve squadrons at different stations in England from which service squadrons were built up and broken off as they were completed. Generally speaking, the reserve squadrons carried out the preliminary training of pupils on Maurice Farmans only. These pupils, as they qualified, were sent on either to the C.F.S. or to a service squadron, where they completed their training. At first the C.F.S. was equal to the demands made on it by the Expeditionary Force to replace wastage, but as the wastage increased new service squadrons at home also had to produce their quota of trained pilots for the Expeditionary Force. The progress of these new squadrons was therefore governed by two factors. First, the output of material on which to train their pilots; and, secondly, the rate at which some portions of their trained pilots were taken away to replace wastage in the field. And eventually, as resources became available, we had to start reserve squadrons to carry out advanced training as well as preliminary. At this period our two great difficulties were: (1) A shortage of competent instructors; (2) scarcity of aeroplanes and engines. And we had a very hard struggle to make both ends meet during the winter of 1914-1915, after which matters began to very slowly improve. At the same time the experience of war taught us that a pilot required many qualifications besides those of flying pure and simple. First, wireless, photography and bomb-dropping all came into vogue and demanded extra training. A little later fighting in the air started, and this involved instruction in aerial gymnastics and the use of machine guns. In the latter half of 1915 fighting in the air became a really serious proposition, and consequently the wastage grew much larger, so much so that during the winter of 1915-1916 the training of pilots had to be considerably forced and hastened in order to keep up with the demands, and the output of new squadrons had to be considerably delayed in order to get training on to a more thorough basis.

Now I will take the career of a civilian who wishes to join the R.F.C. now. He first has to join the service as a cadet and go through a course in the Cadets' School, at which military subjects, pure and simple, are taught. He gets a grounding of drill and discipline, care of arms, interior economy, military law and the use of the machine gun; this course lasts about two months. From this the cadet is sent to a Flying Corps training school, where he begins his technical training on the ground. He goes through a course in the care of engines and rigging. He is given some ideas on the theory of flight. He is taught wireless signalling and receiving. He gets instruction in the care of machine guns, in the use of the camera, in map reading, in the observation of artillery fire with models, and in his spare moments he gets a certain amount of drill. This course lasts another two months, and if he gets through this successfully he is given a commission on the General List. He then joins a preliminary training squadron as a pupil, and starts his instruction usually on the Maurice Farman, his training both in military and technical subjects going on concurrently. After reaching a certain standard of efficiency and having completed a certain number of hours in the air, he is sent on to an advanced training squadron or service squadron, where he learns to fly service types of machines for military purposes and eventually qualifies for his wings. He is then gazetted as a Flying Officer of the R.F.C. and posted to a service squadron. If he shows exceptional promise as a pilot after his qualification he is sent to the C.F.S., where he is given extra higher instruction on fighting scouts. During the period of advanced training he goes through a course of aerial gunnery away from his squadron. The total time in the air usually required to reach the qualification stage is about 30 hours solo in present circumstances, but, of course, the length of time that it takes to reach this standard depends entirely on the weather and the number of aeroplanes available. During the winter it works out to about four months, but in the summer it is considerably shorter.

The way in which war has forced a higher standard on us is remarkable. There is only one point which has simplified training during the past two and a half years. The modern designed aeroplane and the latest engine makes flying pure and simple much easier than it used to be. Aeroplnaes are usually comparatively stable, and engines have a considerable reserve of power, and are far more reliable than in the old days, and these two factors have helped a good deal in the training of pilots.

To sum up, before the war flying was comparatively difficult and was the chief factor in the pilot's training, military qualifications being considered of quite secondary importance. Now, flying up to a certain standard is extraordinarily easy, but the standard of military qualifications required is getting higher and higher, and more difficult to attain, and at the same time the quality of flying demanded is growing greater every day. So our task at home grows harder.

There is no such thing as a perfect aerodrome, and even a possible one is very difficult to find in England without either interfering with somebody else's rights or involving an enormous amount of labor and consequent waste of time. Climatic conditions and a sound soil are the two most important factors when selecting an aerodrome. In England, however, climatic conditions are so varied and unreliable that one can hardly say what part of England is best. So in this country a sound soil is probably the most important factor. After that, if the aerodrome is not a very big one, open ground in its immediate neighborhood is of great importance. A debatable point is always how many pupils or how many aeroplanes can be effectively and safely trained and used at one aerodrome. We have generally assumed that the ideal number was about 60 pupils, and that for 60 pupils, including machines under repair and in reserve, we wanted about 60 aeroplanes, but of late bigger stations have been organized, although I have no statistics to prove which is the better and most economical system. Only a certain amount of room in the air and every one ought to be out in fine weather. An aerodrome, if possible, should be large enough to provide straights of about one mile in length in several directions. The use of these straights accelerates the first stages of preliminary training very greatly, but they are not absolutely necessary, and in a good many of our aerodromes at home no straight exists.

The question of instructors has been a very difficult one from the start of the war. I suppose only about 10 per cent of our flying officers are really good instructors. I have often had qualms on the subject, but the results have really been better than I expected originally. Instructors have many and various methods, and it has been suggested that definite orders should be issued as to how pupils should be taught to fly. I have never been able to bring myself to issue such an order for fear of hampering initiative. The qualities required in an instructor are almost precisely the same as the qualities required in a man whose business it is to break in young horses—*infinite patience, great sympathy, good hands, and a clear, steady head.*

The next point which affects requirements of training is the provision of aeroplanes and engines. Here again controversy is eternally raging as to the best types to employ. Before the war the general idea was that a beginner should be taught on the box kite, and this idea has lasted inasmuch that to-day nearly all our pupils start their instruction on a Maurice Farman. Personally I have been opposed to this system, but I may be wrong and have given way to the majority, but I think from the instructor's point of view the Maurice Farman is a very nice safe machine on which to get the pupil through his first experience of dual control in the air, although in the actual movements necessary for controlling the machine it is different from almost any other machine in the service. The 80-Gnome Avro has, beyond the Maurice Farman, been our standby in advanced training, and is a thoroughly good machine for this purpose, light in handling, comparatively sensitive and not too difficult to fly. For some time pupils were successfully started on 80-Avros, but when Maurice Farmans are available in sufficient quantities the concensus of opinion has been that it was better to stick to that machine for preliminary training. Now, however, we have a new type, the first of which has just flown, which I hope will eventually eliminate the box kite type of training machine altogether. Another point on which much argument arises is the use of stable machines for training. When stable machines first came in the old conservative pilots shook their heads sadly and said that you could never make a good pilot on a stable machine; that idea has died out, but there are still many instructors who insist that to make a good pilot he must first be trained on an unstable machine before being allowed to go on a stable one, to make him careful, but after all landing is the great thing, and stable machines are just as hard to land as unstable. Personally I am not at all sure that this is correct, and I believe that a pilot trained on stable machines from the start, after he has had about 30 hours' air experience, will be so confident and have such a good idea of what a machine ought to do in the air, that he will fly an unstable machine without even realizing its instability, that is to say, of course, if he has been properly taught. So far as engines go, it is only natural, through the demands of war, that we have been forced to use our obsolete engines for training purposes. As a matter of fact, these obsolete engines are just what are not required for training purposes, because, being of an early type, they are more

*Abstracts from a paper by Brigadier-General W. S. Brachner before the Aeronautical Society (England) and reported in *Flight*.

liable to failure than the modern types, and engine failure is just what one wants to avoid in training. The output of the trade, however, has precluded the manufacture in numbers of a special training engine. But now that the obsolescent engines are of newer types, this difficulty will tend to disappear.

Now to turn to the actual process of training. I will consider it under two heads, technical training both on the ground and in the air and military training both on the ground and in the air. The first portion of technical training is the care of engines, rigging of aeroplanes, the use of the compass, the use of instruments and other such details. This is carried out at the two schools of military aeronautics; engines are taken down and erected and are run, samples of as many types as possible being provided to give the pupil wide experience. The same applies regarding the rigging and erection of aeroplanes, and pupils are made thoroughly conversant with the use of all the instruments. Thus a pupil before he actually learns to fly really has some knowledge of his engine, his machine, and its instruments. He then goes on to preliminary and advanced training squadrons, and continues to learn the enormous amount there is to learn on these heads by practical experience both in the air and in the squadron shops.

A very debatable point in the actual training in flying is whether reserve squadrons should train pupils all through—*i. e.*, from the very start up to the time they get their wings—or whether, as is the system at present, they do preliminary training with one reserve squadron and go on to higher training in another. There are certain arguments for and against both systems, but we have adopted the second. The greatest argument in favor of the first system is that the one instructor can take a pupil and really get to know him and follow him right through his training; but practically preliminary training takes a shorter time than advanced training, and the system of military training is simplified by separating preliminary flying training from the advanced flying training. One great advantage of placing preliminary training and advanced training in separate squadrons is that the squadrons can be homogeneous in equipment. So much for the technical training; it is fairly simple, given a sound instructor and good weather.

I have already explained the many military qualifications demanded from the modern pilot, and the military training on the ground, like the technical, is carried out at the schools of military aeronautics, where the pupil gets a good grounding in the use and care of the machine gun, wireless, artillery observation, photography and bomb-dropping, and this training he completes from practical experience when he gets on flying instruction.

During his preliminary training in flying instruction his military training is still theoretical and on the ground, but in the advanced training squadrons he begins to fly in formations and to drop bombs or their equivalent at a target. He carries out practical artillery observation by means of powder puffs on the ground which represent the bursting of shells, and he is sent out across country to photograph various points in the neighborhood and until he has proved himself efficient in all these operations he cannot be a qualified pilot. Fighting in the air is also practiced by various methods: Two machines may be sent up to maneuver against one another, both trying to attack; or the pupil is sent up whilst the instructor tries to attack him or *vice versa*. or the instructor goes out and attacks a group of his pupils returning from a cross-country flight, and so on.

I think I have made it fairly clear that training in aviation from the military point of view is getting more and more complicated, but I hope that I have also made it clear that actual flying from the practical point of view of getting from one place to another has become very easy and comparatively safe, and that therefore in peace every one who can should take it up as a means of travel and a means of recreation. The great factor against aviation for such purposes is our uncertain climate, but with experience and with reliable engines it is possible to fly in almost any weather short of a thick fog, a hurricane or a violent thunderstorm. All these can be avoided by skill in navigation and a certain amount of weather wisdom.

There is always a great controversy as to the best age for flying. I think that there is no doubt the best age to learn to fly is as young as possible, just as a boy learns to ride, but during war this is impossible, as the pupil would be too young to fight. We take a few below the age of 18 now, but generally speaking 18 is rather young for the great strain of active service, and I prefer the man of 20 to 25. When you come to the older category I think everything depends on the life which the individual has led. A man of between 35 and 40 who has lived a hard life and is a good horseman will probably turn into a good pilot quicker than the man of from 25 to 30 who has spent his life in an office or doing nothing, but as a rule the older man will not stand the strain of active service fighting as long as the young man. The quality of horsemanship is quite a useful one in any would-be pilot. The requirements are just the same—good hands, a good head, steady nerves, and judgment. Flying is perhaps a little easier than riding because you sit in a comfortable armchair in a quiet machine instead of on a slippery saddle on a very lively horse. Generally speaking, I think it is only youth that makes it possible to become a really star pilot who can do almost anything in the air without loss of nerve. Probably the young man of 18 to 25 makes the best fighting pilot, whereas the older man will do best on long reconnaissance and artillery work, where less dash and more experience and endurance are required.

Very much depends on the character and temperament of each man, and the ideal in training would be to teach almost every pupil somewhat differently.

A point of inerest in this connection is the relative status of pilot and passenger, flying officer and observer. The Germans and ourselves are quite different. The Germans have a certain number of officer pilots, but a good many N.C.Os. Their observers are all officers, and are supposed to take charge when in the air. As a rule I think their observers very seldom become trained pilots.

In the R.F.C. almost all pilots are officers—and the N.C.Os. very soon get commissions if they do well, and the observers, although officers as a rule, are absolutely under the control of the pilot. Our observers after a certain period of successful work in that capacity are allowed to learn to fly, and usually make very good pilots. Two completely opposite theories, of which I think ours has proved to be the best. I think there are certainly cases where German N.C.O. pilots have shown cowardice, and the officer observer has been unable to control them. Anyway, we go on with our system, and it works well, its only drawback being that we lose our observers just as they are getting really experienced, but experience is often equivalent to tiredness and caution.

Another point of interest is the danger connected with training in flying. During peace the first consideration was to avoid accidents, which roused foolish questions in the House, and in consequence delayed progress and wasted everyone's time. Since the war started we have got away from that sort of nonsense, with the result that we take far greater risks than we used. In spite of this, the percentage of accidents has not really risen appreciably very much. A good many deaths are reported in the papers and frighten a certain number of people, but when you compare the number of deaths with the very large number of pupils in training and the very large number of hours in the air accomplished every day, the price is not great, and in the present stage of aviation the fact must be fearlessly accepted that no progress can be made without a certain cost in human life. Under peace conditions the ruling consideration will be the safety of the pupil, and we shall then be able to keep a man under training longer and take him much more slowly in the early stages, give him more instruction on the ground by means of various mechanical devices, and render him almost immune from the ordinary accident. There is one very satisfactory feature in looking back through the accidents which have occurred since the beginning of the war in training—there have been extraordinarily few cases of breakage in the air, which speaks very well for British construction and inspection. The most common type of accident is engine failure, followed by an effort to turn sharply into a possible landing-place and losing speed on the turn, which results in a nose-dive and serious smash. Even good and experienced pilots are prone to do this, and to me the only cure appears to be the avoidance of engine failure. This will assuredly come in peace, when we can devote more energy towards real reliability in the engine instead of extreme lightness and exaggerated performances.

As an officer who has been responsible for training in the War Office now for four years, I feel that I have been wonderfully lucky in having the finest material in the world to work on both for instructors and pupils. The Englishman may be conservative, but he is certainly the finest pilot in the world; the value of all the old British characteristics which made us masters of the *sea* is intensified in the *air*, and they will make us masters of the air yet, in spite of our politics and our system of government, and all the many obstructions to progress which will assuredly spring up as soon as peace is declared. War has been the making of British aviation, and we must look to it that we preserve and develop the fruits of this war so far as aviation is concerned. Now by technical training in the air I mean instruction in flying pure and simple, without any direct reference to its military uses. During peace a good many pilots learned to fly by the light of nature. They were just put into a machine and made to taxi about on the ground until they knew the controls, and then pushed off into the air, and left to take their chance—a thrilling moment both for themselves and their instructors. Now I think it is fairly well established that dual control is an absolute necessity. It gets the pupil into proper habits in the early stages of his training, and this he cannot really dispense with unless he is a heaven-born genius who takes to the air as a duck does to water, and there are certainly some men who seem to require no training at all.

The most difficult part of flying is landing.

The stereotyped method of starting instruction is on a Maurice Farman, with dual control, up and down "straights," gradually giving the pupil more and more control until he lands properly. In fact nearly the whole art of flying lies in landing, and a man who lands well *under any conditions* will certainly be able to do anything else in the air well on his own, given a sound nerve. After the first few solos on an easy type of machine, the pupil usually returns to dual control on a faster and more efficient machine—after many and wearisome circuits and landing with dual control, he is sent off on his first cross-country flight, another really thrilling experience. Before being allowed to do this, however, a pupil should be able to land within a marked chalk circle with his engine stopped from any height, and to have practised landing slowly over obstacles.

During this period of training one of the great bones of contention used to be the advisability of training a pupil to fly by means of his instruments as opposed to balance. Instruments used to be unreliable. Instruments of late have become more and more reliable, and personally I am the greatest believer in using them for training. After a little experience with instruments, as a guide, any intelligent man will find himself working without them instinctively, and they will have tided him over many dangers in the early stages.

I have already talked about the stability, and I think the day will come when an unstable machine will be looked upon as impossible. Another very interesting point is the value of air experience as a passenger before learning to fly. I used always to be of opinion that a large amount of passenger flying would almost teach a man to fly before he was asked to touch the controls at all, but I have been somewhat disappointed in actual results.

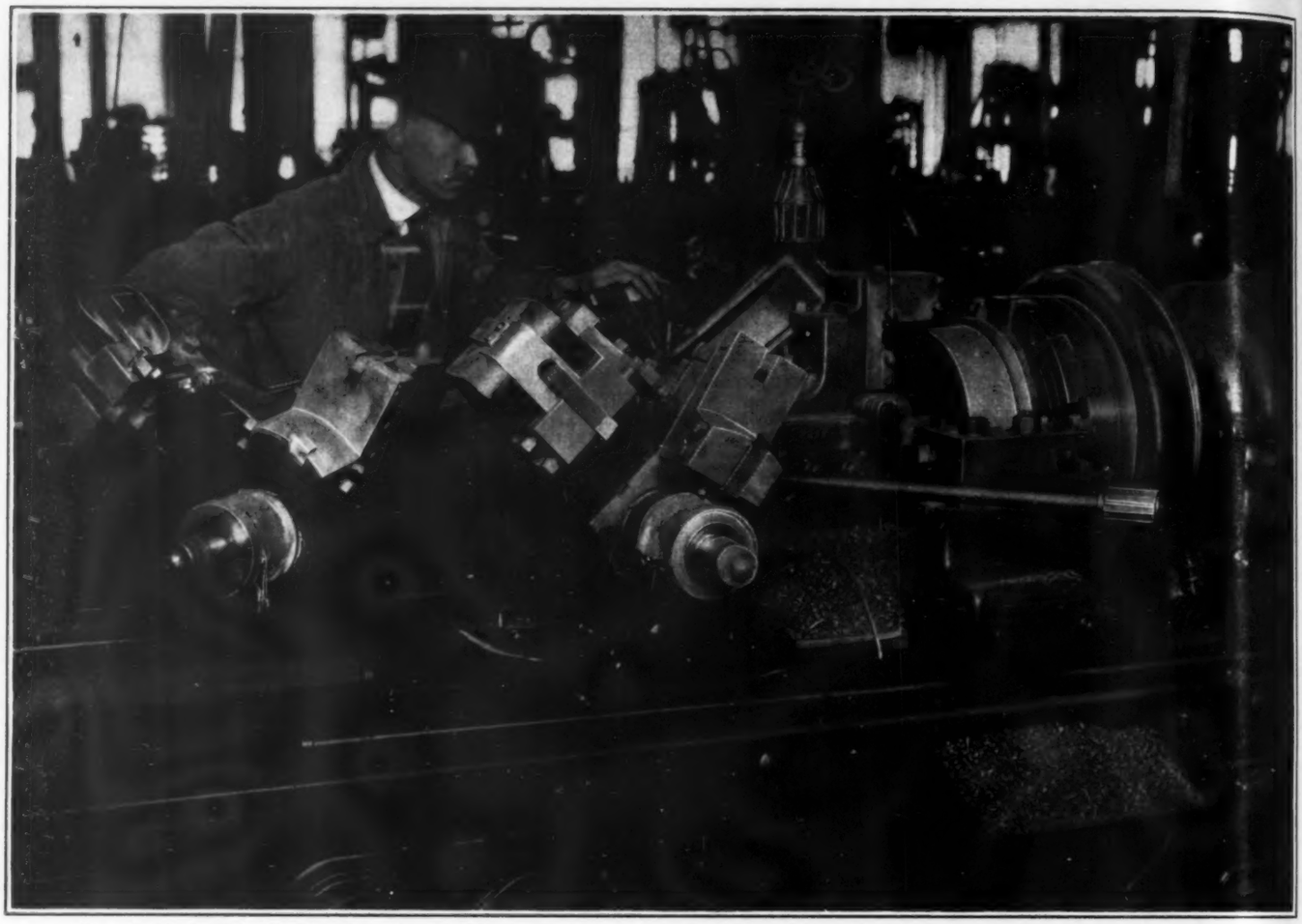
Well, once the ice is broken by the first few cross-country flights, progress becomes rapid, and the pupil soon begins to really handle his machine in the air, and to practise real aerial gymnastics, such as steep spirals, loops, tail-slides and so on. Then slowly the air habit begins to grow on the man, if he is ever going to be any good, and experience—and nothing else—makes it possible to land almost anywhere in a bad country with the engines stopped dead, and to drop down faultlessly on to a strange landing-place without any indication of the direction of the wind or the slope of the ground, and to maneuver round and over storms, and find your way regardless of weather. As the pupil goes on the best form of training is to force him to fly in really bad weather. There is nothing which gives so much confidence as a successful bout with a nasty day. Weather has extraordinarily little effect on flying as long as it is sufficiently clear to see; fog and very heavy rain are the two really undefeatable factors in aviation. The war has taught us to laugh at weather. It is only four years ago that "bumps" were looked upon with the deepest reverence and respect, and there were certain crossings over the rivers and hills around Salisbury Plain which were usually avoided except by the boldest. To-day, however, no one ever thinks of them, and yet almost exactly the same machines are being used for preliminary training as were being used then. It is a very good example of the wonderful growth of confidence in the last few years, which has done much to push on the progress of aviation.

On the whole flying itself is so easy that pupils suffer from over-confidence. Careful teaching is essential, and very careful instructions as to the best method of meeting any emergency, such as a spin or a nose-dive, and it is only quite lately that we have had any authoritative statements as to how to compete with these situations, and even now there are probably people who differ as to the best course to follow if you find yourself nose-diving out of a cloud.

Anyway, the actual assimilation of the art of flying—or the air-habit—is largely a matter of air experience, and, given nerves and health and common sense, there are very few Englishmen who won't make good pilots so long as they have sufficient experience.

Eskimo Schools

THE keynote of our school system for the Eskimo is its direct relation to the village life. Thus the school republic becomes the village council, the school garden soon becomes the village garden, the cooking class becomes the bread-baking class for the village, the clean-up of the school ground becomes the village clean-up. —*The Eskimo.*



An automatic turret lathe that performs twenty different operations on an automobile engine fly-wheel in fifteen minutes, during which it removes twenty-four pounds of superfluous material

Quantity Production

How Automobile Building has Stimulated Mechanical Processes

MUCH has been written of the wonderful and widespread influence the automobile has had on human life, but there is one phase of the industry that has been given but little attention, and that is its influence in stimulating mechanical processes and the improvement in machine design, for these are things that are of importance not only in the manufacture of automobiles, but have had a vast influence on almost every manufacturing process in which machinery is employed. When the automobile was first introduced the methods of manufacture were, as compared with today, slow and expensive, and if conditions had remained as they were, the automobile would have remained only as the toy of the wealthy. The vast possibilities of the new creation were, however, early realized, together with the immense market that would be opened if the cost could be reduced to a figure that would put the vehicle within the reach of the average man; and to do this it was seen that the cost of production must be reduced. Competition also came in as a powerful factor, and the result is that today the big automobile factory is one of the marvels of the world.

The keynote of automobile manufacturing today is quantity production, which means that cars must be built quickly and cheaply; but cheapness does not mean poor workmanship, for the automobile of today is as far superior to the machine of fifteen years ago as it is in refinement of design and efficiency. Every feature of automobile engines has undergone radical improvement; it is more powerful for equal weights, more flexible, more economical and more durable, and all of these betterments are the result not alone of more scientific design, but of better materials and workmanship. Incidentally it may be noted that the improvements in automobile building have had a decided influence on the steel industry, many new varieties of steel possessing special qualities demanded for particular parts of automobiles having been developed in response to the demands of this industry; and other metal trades have been similarly affected.

It should not be inferred that the wonderful improvements in machinery and mechanical processes here referred to would not have been made but for the coming of the automobile, for it was but the natural trend of modern manufacturing; but it is unquestionable that the demands of the automobile greatly hastened the movement which has demonstrated the possibilities of machinery and quantity production long before these results would have developed naturally.

The subject of quantity production, which includes cheap, but good, production is a large one, but a general idea of how it is done can be gained by an inspection of the accompanying illustrations that show two details of operations. In the photograph on the first page of this issue is shown a machine that drills eighty-one holes at once in an automobile crank case. By the methods in vogue twenty years ago, to do this work it was necessary to locate the position of each one of these holes, one at a time, and then to adjust the part on the drill press for each hole, which must not only be properly located, but must be bored accurately in a particular direction. Both of these operations required a skilled and experienced mechanic: and even with the most expert workman it may be imagined how long it would require to do the work on a single crank case. All of this meant a very great expenditure of time and money; and, as every other operation on an automobile had to be done in approximately the same way, it is evident not only that the cost of producing a car would be too great for the average man to pay, but that to turn out 100,000 cars would require a plant of prohibitive size, even if a sufficient number of experienced workmen could be found.

To meet these conditions existing machinery had to be revised, and special machines designed that would not only shorten the process, but permit it to be performed by cheaper labor, while maintaining or increasing the accuracy of the work done. The first step was the development of the "jig," which, in the present instance is in the form of a cast iron frame in which the part to be operated upon can be tightly clamped in an invariable position. In the walls of this frame the various holes to be bored are very accurately located and drilled, and to protect these holes in the jig from wear, and to insure that they will maintain their correct position, each hole is lined with a hardened steel bushing with an aperture that will snugly fit the particular size of drill required at each position. This jig, with its bushings, guides the drills to the proper points on the part being made. Moreover, the jig is so made that, when it is placed on the bed of the drilling machine, each drill will bore its hole in the right direction.

To operate with this jig special drilling machines were also developed which had the requisite number of drills. In the machine shown these drills are all fixed in certain positions, as a sufficient number of parts are made to keep it busy throughout the year; but when this is not the case the drilling machine is so built that the drills may be shifted, and adjusted for operating on a variety of different parts.

It will be seen that, with the improved machine, operated in conjunction with a suitable jig, not only is the work of boring the holes in this part shortened over eighty times, but that the entire process can be performed by a man of ordinary intelligence, after a few minutes' instruction, and the combined saving of wages, time, number of machines required and size of plant is enormous. This same system of jigs can, moreover, be applied to a great many other classes of machinery throughout an ordinary machine shop, with similar economies.

Aside from the improvements that have been made in machinery, generally, the universal introduction of jigs and fixtures has not only greatly increased the speed of production, but these devices have made it

possible to utilize great numbers of ordinary laborers, who otherwise would not be able to find employment. It may be explained that fixtures play a similar role to jigs, the main difference being that they are permanently attached to a machine, and enable an unskilled operator to properly place the piece to be operated upon in the machine. These two important classes of machine adjuncts, jigs and fixtures, each devised for a particular use, are very expensive to build, as they must be designed and made by the highest class of expert mechanics; but where large numbers of identical parts are to be made they more than pay for themselves. Indeed, a factory fully equipped with the most modern machinery would be of little avail for quantity production without its complementary equipment of jigs, fixtures and gages; and the fact that all of these devices must be specially designed for the projected work, and painstakingly wrought by hand, so to speak, explains why it takes so long for a new manufacturing enterprise to get into operation.

The American public has not been able to understand why it is that, with all of our immense and splendidly equipped factories, there should be any difficulty in promptly supplying our armies with the necessary rifles and other munitions of warfare, especially as these same factories have been turning out such quantities of similar material for the Allies. The explanation lies in this question of accessory tools. The guns and other materials for the Allies are of different construction and sizes from those adopted by the United States, and while the machinery is there ready for use, it will take many months to produce the thousands of jigs, fixtures and gages necessary for quantity production of our own material, and without these the output would be insignificant and imperfect.

Referring to the other illustration, accompanying this article, we have another description of labor saving machinery that has been wonderfully elaborated of late years. This is the automatic lathe, which has created a revolution in mechanical processes, and which is built in a great variety of styles. The particular machine shown is making fly wheels for automobile engines, which it turns out at the rate of one in every fifteen minutes. The machine tender places a rough casting on the faceplate of the machine and pulls a lever that puts a pneumatically operated chuck in action which securely clamps the piece of work in place. Then he pulls another lever to start the machine, which proceeds to form the fly-wheel, twenty different operations being performed automatically, accurately and rapidly. On the bed of the lathe in front of the casting is a six-sided, revolvable head, on each face of which is mounted one or more tool carriers. As the casting steadily revolves the tool head advances gradually towards it, bringing one or more tools into action, each of which performs a particular cutting operation. When the work of the first set of tools is finished the head comes into contact with a stop that not only prevents further cutting action, but sets into operation mechanism that withdraws the head from the work and turns it around to bring the next set of tools into position in front of the work. The head again advances to perform another series of cuts, and this operation is repeated until each of the sets of tools has performed its work, when the machine stops. One attendant can take care of three of these machines, for all he has to do is to put in and take out the work, start the machine and watch its operation to see that the adjustments do not alter, or the tools become dull.

Before the development of this machine, it was necessary to perform each of the twenty operations separately, frequently transferring the piece from one lathe to another, all of which consumed much time, made accurate duplication difficult and greatly increased the possibility of serious errors and waste.

The cases here cited are but two out of hundreds that can be found not only in automobile factories, but in every large manufacturing plant, by which cost of production is diminished, the product increased and the quality improved. Hundreds of the most ingenious special machines have been designed since the possibilities of automatic machinery have been realized, and these, in conjunction with efficiency systems, have not only vastly improved the quality of the modern automobile, but have made it possible to put it on the market at a fifth of the price that machines of a corresponding size and power would have cost in the early days of the business; and, as has been said, the demand and the competition in manufacturing automobiles have been largely instrumental in hastening the development of manufacturing processes.

Distant Control of Aircraft by Whistling

An Australian inventor has developed a new method of distant control, which is, he considers, a great improvement on the wireless method, since it may be so arranged as to absolutely prevent interference by "unauthorized persons." A demonstration of the device was recently given before a representative of *Flight* (London) who gives the following description.

The natural interpretation of the term "unauthorized persons" under present conditions is, of course, "enemies." Before proceeding to indicate the nature of this invention, it may be well to point out that distant control of aircraft is only one out of a great number of applications of which the instrument is capable. In fact, using it for this particular purpose is, perhaps, in the inventor's mind merely a minor "side line," fraught with possibilities as it would appear to be.

Briefly speaking, the inventor makes use, in his device, of the well-known principle of resonance, which will be familiar to most of our readers. Those not already acquainted with it may demonstrate it by the very simple experiment of pressing down the "loud" pedal of a piano and playing a note on some other instrument—a violin, for instance. The corresponding note will then sound on the piano.

The resonator consists fundamentally of a telephone transmitter and receiver, facing one another and placed a short distance apart, the space between them being enclosed in a cylindrical casing which confines the air, thus amplifying the reaction between transmitter and receiver. To the back of the receiver is attached a tube in which works a piston operated by a short rod. By moving the piston in and out the length of the air column behind the receiver is changed, and consequently the note emitted when the diaphragms of transmitter and receiver are vibrated is altered correspondingly. The principle of the whole arrangement will be better and more easily understood by reference to the accompanying diagram. The telephone transmitter is coupled to the primary current and the receiver to the secondary current. From one of the terminals of the transmitter a wire runs through a suitable resistance, to a switch, hence through a battery, through the primary circuit of an induction coil, to an ordinary post office relay, and from there back to the second terminal of transmitter. The wiring from the receiver is, it will be seen, connected up to the secondary circuit of the induction coil. When the armature of the relay moves over it provides short circuiting by the two wires shown in the diagram running to each side of the secondary coil.

It will now be seen that when the diaphragms of the transmitter and receiver are vibrated by the proper note, determined by the position of the piston in the tube, and no other note will cause them to vibrate, the relay is brought into play and closes the local current which may then be used, via suitable means, of course, for starting or stopping an engine, operating control surfaces, releasing bombs, etc.

In the model framework of a dirigible on which the principle of distant control was demonstrated, there were, as we have already indicated, three small electromotors, each driving a propeller. As demonstrated the sequence of operation of the three motors was, in fact, predetermined by reason of the multiple switch employed for throwing them into gear, the same note being used for initiating the control of all the motors. When rigged up for actual use on aircraft each motor and movement would have its particular note, so that no fixed sequence would have to be followed. This, for instance, one note would correspond to right rudder, one to left rudder; one to elevating, one to depressing; one to accelerating the engine, and one to throttling it down. In this way any evolution of an aircraft could be controlled from the ground, the necessary notes being produced by some suitable instrument, as, for instance, a siren, in which the note could be altered by varying the speed of the siren. Care would, of course, have to be taken that no note likely to be produced on board the aircraft itself, either by the engines or by the bracing wires humming in the current of air, was employed for control. In fact, there seems to be no reason why notes of such a pitch as to be inaudible to the human ear should not be employed.

On the model demonstrated it was possible to set the machinery in motion by running up and down the scale until the right note was found. The inventor claims,

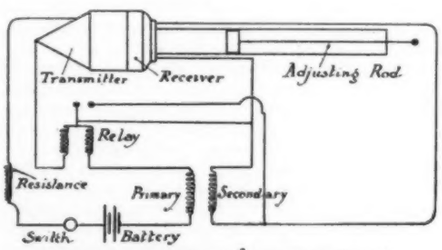


Diagram of a device for controlling aircraft

however, that it would be a very simple matter to arrange a combination whereby it would be necessary to sound the given note, not once but several times, with predetermined intervals, before the result was obtained, thus providing in effect an equivalent to the combinations used on safes, and absolutely preventing outside interference. It is mainly in this respect, we understand, that the inventor claims superiority of the resonance method over the wireless system, in which latter a coherer must be used, and which is therefore open to the criticism that it may comparatively easily be interfered with.

As regards the practical utility of this very ingenious device to aircraft work, the number of forms this might take appear to be legion, and although many difficulties suggest themselves, doubtless they can be overcome. Even if they cannot, that does not detract in the least from the ingeniousness of the device. The inventor has, as already mentioned, ample scope for the application of the device to other fields of engineering. Thus, for instance, for telegraphic purposes the resonator renders possible the sending of a great number of telegrams over one wire simultaneously, with the further advantage that "tapping" the wire can be made practically impossible. Communication can be maintained between a central station and each of a number of trains, thus minimizing the danger of collision, and there are numerous other applications possible, which we cannot deal with here.

Action of Light on the Formation and Decomposition of the Hydrogen Halogen Acids

The authors have investigated the action of light on the gaseous systems hydrogen iodide, hydrogen bromide, hydrogen chloride, and their components. The reactions have been effected by means of a mercury lamp in both quartz and uviol glass apparatus. In all three cases equilibrium has been reached from both sides. In quartz apparatus the decomposition proceeds to the extent of 92.3 per cent in the case of hydrogen iodide, and this is reached in ten minutes; the formation proceeds to 7.6 per cent. In both uviol glass and ordinary glass there is a decomposition of 100 per cent and no formation in the case of hydrogen iodide. With hydrogen bromide there is 100 per cent decomposition in quartz, 20 per cent in uviol glass, and no decomposition in glass. The amount of formation of hydrogen bromide is zero in quartz, 80 per cent in uviol glass, and 100 per cent in glass. In the case of hydrogen chloride there is 0.42 per cent decomposition and 99.58 per cent formation in quartz and 100 per cent formation with no decomposition in uviol glass and ordinary glass. In the case of hydrogen bromide the reaction is complete in four hours and with hydrogen chloride in less than five minutes. The use of the three types of apparatus shows the effect of the different spectral regions; in quartz, light down to 220 $\mu\mu$ is active, in uviol glass to 254 $\mu\mu$, and in Jena glass down to 300 $\mu\mu$.—Note in *Jour. Soc. Chem. Ind.*, on an article by A. Coehn and K. Stuckardt in *Z. Phys. Chem.*

Colloidal Graphite in Oil

The efficiency of colloidal graphite lubricants depends on the purity of the graphite, the proportion of this element present, and the stability of the colloidal state on standing. A method devised by Freundlich (this J., 1916, 590) for estimating the graphite consists in the addition of benzene and a suitable electrolyte to cause flocculation. After standing six to seven hours, the graphite can be filtered off. A more rapid method devised by the author consists in adding benzene to the mixture, and without further standing, filtering through a Gooch crucible packed with a finely divided powder such as Fuller's earth. The filter is then washed with carbon tetrachloride or chloroform, so as to remove soluble impurities separated from the oil. The stability of the suspensions varies with the viscosity and nature of the oils, and can be measured by allowing a column of the mixture to stand for a prolonged interval, and determining the amount of separation by observing the loss of opacity in the top layer, or by analysis. The settling can be accelerated by diluting with an oil of low viscosity.—Note in *Jour. Soc. Chem. Ind.*, on an article by D. Holde, *Chem. Zeit.*

Damage to Seasoned Hard Wood by Lyctus Beetles*

The Insects Responsible, Remedies and Preventive Measures

By A. D. Hopkins, Forest Entomologist, and T. E. Snyder, Specialist in Forest Entomology

THE sapwood of seasoned hard wood material of all kinds, both finished and unfinished, especially of hickory, ash, and oak, is often ruined by yellowish-white grubs from one-eighth to one-fifth inch in length which burrow through the solid wood in all directions and convert it into powder. These grubs are the young, or larvæ, of beetles, known as powder-post beetles. Wood that has been seasoned a year or longer is especially liable to this peculiar type of insect injury, which sometimes amounts to from ten to fifty per cent of neglected material in storage. Powder-post damage by these beetles is widely distributed over the world and the consequent losses have been severe.

Under the general class of powder-post injury the work of insects representing several species and groups of species of beetles may be found, but by far the larger part and the most serious damage and losses are caused by different species of Lyctus.[1]

Infested wood may be detected by the fine, flourlike powder found on or beneath piled or stored hickory, ash, oak, and other seasoned hard wood products. During the first year of infestation the powder comes from exceedingly minute holes in the wood, but after the second year the small holes from which the beetles have emerged are more or less conspicuous, and from these the powder will fall when the infested material is moved or jarred. When the wood is cut or split the interior is often found converted into a mass of closely packed powdery material which has been held together by an outer thin shell and intervening fibers of sound wood. The grubs, burrowing through the solid wood in all directions, have pulverized the wood fiber and have packed their burrows with this powdered wood. The injury by Lyctus beetles is always confined to the white wood or sapwood, although the heartwood is sometimes penetrated when the matured beetles are emerging from the wood.

A great variety of seasoned hard wood products is subject to powder-post damage, especially hickory, ash, and oak machinery and implement handles, but persimmon, osage orange, black walnut, butternut, maple, elm, wild cherry, locust, poplar, sycamore, eucalyptus, sassafras, orange wood, fig, bamboo, and other woods are also attacked.

Second-growth sapwood of the best quality is particularly liable to attack and serious injury, especially when it has been stored or piled in one place for two or three years or more.

The loss to seasoned hard wood products ranges from one to fifty per cent, sometimes representing thousands of dollars to a single manufacturer or dealer who neglects to adopt the proper preventive measures. The affected articles are not only reduced in value, but frequently are rendered worthless for the purposes for which they are intended. In the aggregate the direct financial loss that has been caused by these beetles in this country has amounted to hundreds of thousands of dollars annually. The loss increases with the length of time the infested stock is held in storage. In certain cases powder-post injury may be a menace to human life as in the weakened wood material of vehicles, ladders, etc.

CHARACTER OF THE INSECTS WHICH CAUSE THE DAMAGE

The Lyctus beetles are small, slender, somewhat flattened, brownish to nearly black beetles, which, upon emerging from the wood where they breed and pass the winter as larvæ, fly or crawl about in search of suitable wood material in which to deposit their eggs.

There are four stages in the life history of these insects —namely, the egg, the larva or grub, the pupa or resting stage, and finally the adult or beetle.

The egg is deposited in the pores of the wood by the female beetle soon after it emerges from the wood. The minute larva which hatches from the egg proceeds to burrow in and through the wood in all directions, feeding and growing as it proceeds, until it has attained its full size. The full-grown larva is a yellowish-white grub ranging in length from one-eighth to one-fifth of an inch, with three pairs of legs, and with the tip of the body curved under toward the head. Upon reaching maturity as a larva it excavates a cell at the end of its burrow and in this transforms to the pupa. Later the pupa changes to the adult beetle which can fly in search of suitable places to lay its eggs.

Seasoned wood is attacked by these beetles because the chemical changes which take place in the process of seasoning render the nutritive substances in the wood, such as sugar and starch, especially suitable as food for the development of the young or larval stage.

Each female beetle deposits many eggs,[2] and many females oviposit in a single piece of wood, so that the combined work of their numerous progeny, burrowing through the wood in quest of food for their development, results in the complete destruction of the interior wood fiber and its conversion into a mass of fine powder. If the first attack and the first generation do not accomplish this destruction, subsequent generations will follow in the same wood until nothing of the solid fiber is left but a thin outer shell.

The different kinds of Lyctus beetles vary somewhat in their habits and seasonal history, but there is a general similarity.

The larvæ remain dormant or active in the wood, according to the temperature of the place where stored, and in consequence infestation in wood stored in cold places may pass unnoticed. If the wood is removed from outdoors, open storage sheds, or other places which are cold in winter, to the dry kiln, the dormant larvæ start to work in the wood, as shown by the ejection of boring dust or powder. Handling or jarring infested wood appears temporarily to stop the activity of larvæ contained in it.

In general, the adults or beetles are active between the first of March and the last of July at Washington, D. C. (about latitude 39° and longitude 77°, and practically at sea level), but the period varies according to the species, the temperature of the storerooms, and the geographical location. According to the senior author, the variation due to latitude, longitude, and altitude from a date at Washington, D. C., will be approximately four days for each degree of latitude, 5 degrees of longitude, and 400 feet of altitude, being earlier in the season southward, westward, and descending.

So far as known there is only one generation annually.

THE FOUR SPECIES RESPONSIBLE FOR MOST OF THE LOSSES

While, as previously stated, there are many species of Lyctus beetles in the United States, the European Lyctus, the southern Lyctus, the velvety Lyctus, and the western Lyctus are the four species responsible for practically all the losses.

THE EUROPEAN LYCTUS[3]

The European Lyctus beetle is rusty red-brown, slender, somewhat flattened, elongate, and from one-tenth to one-fifth inch in length. The wing covers have single rows of large, rounded, very shallow punctures.

This species is commonly met with in northern Europe under natural conditions as well as in commercial products, especially in England, France and Germany. Therefore it is evident that it was introduced into this country from Europe. In addition to the wide distribution of this species in the temperate zones of the world, it is especially common and destructive in the States north of North Carolina, Tennessee and Arkansas. There are a great many records of damage to seasoned hardwood products by this beetle from this area, including Maine, Massachusetts, New York, Pennsylvania, Virginia, West Virginia, Ohio, Indiana, Illinois, Missouri, Iowa, Michigan and Minnesota. The great number of specimens in the collection of the United States National Museum show but a single record from the South Atlantic and Gulf States, and this is evidently a temporary introduction. Undoubtedly the species is frequently carried into the southern region, but evidently it does not survive there. This beetle is common in commercial products of seasoned hickory, oak, walnut and ash, and occasionally in poplar, wild cherry and locust. It is not recorded from natural growth in the open in this country, but is said to infest such growth, as well as commercial products, in Europe.

Adults of the European species, which has been shown to have a relatively northern distribution in the United States, begin activity as early as the first part of March in its southern distribution and are still active during the first part of August in its northern distribution, general emergence of the adult beetles from infested wood occurring at Washington, D. C., from April until June. The eggs are deposited soon after the adult beetles emerge and are inserted into the pores of the wood by means of a long, slender, flexible ovipositor. General pupation occurs from about the middle of April to the first of May in the District of Columbia.

THE SOUTHERN LYCTUS[4]

The southern Lyctus beetle is pitchy black, slender, somewhat flattened, elongate, and from one-tenth to one-fifth inch in length. The wing covers have smaller, finer, and deeper punctures in more or less distinct double rows. Individuals of this species vary extremely in size, and there is marked difference in size between the sexes, the males often being much smaller than the females. As the result of continued breeding in the same wood for several generations, in confinement the beetles were found to decrease in size.

This species is injurious to hard wood products in and from the South Atlantic and Gulf States to California, Arizona and Nevada. This range probably represents the natural distribution of this southern species. It is frequently introduced into the Northern, Central, and Western States and transported to other countries, but this apparently never results in its permanent establishment except in warm storehouses. There are definite records of its occurrence at Cape Town, South Africa, in lumber received from the southern United States, and at Buenos Aires, Argentina, in the ash wood in refrigerators and shovel handles from the United States.

The southern Lyctus has been recorded as breeding under natural conditions in this country and is common in the Southern States in commercial products, such as seasoned ash, oak, hickory, persimmon and sycamore. Rearing records show that it may breed continuously in the same wood during a period of at least six years, or until all the wood tissue has been converted into powder. The beetles emerge from infested wood of commercial products in heated buildings much earlier than where exposed to outdoor conditions. Owing to the character of the class of commercial products infested by Lyctus beetles, which are often stored indoors, there apparently are no great differences in the periods of activity of adults of species of northern and southern distribution.

Adults of this southern species are active from the middle of February till the last of September in the South Atlantic and Gulf States. General emergence of the adult beetles and mating occur from the middle of April to June, and very few beetles emerge at Washington, D. C., after the first part of July. Egg laying occurs a few days after emergence, and the eggs hatch after a period of not longer than ten days. The winter is passed as larvæ in the wood, and full-grown larvæ are in the pupal cells at Washington by the first part of February. General pupation of the larvæ in the infested wood in rearing experiments at Falls Church, Va., occurred from about the middle of March to the first part of April.

THE VELVETY LYCTUS[5]

The velvety Lyctus is rusty red-brown to black, slender, flattened, and elongate, and from one-twelfth to one-sixth inch in length. The punctures on the wing covers are very fine and obscure and not placed in rows; the fine, dense, yellowish hairs on the wing covers are prominent, which gives the beetle a velvety appearance.

Extensive observations have been made on the habits of this species, which has been recorded as injurious in Texas, Louisiana, Florida, Georgia, South Carolina, Virginia, West Virginia, District of Columbia, Long Island, New York, Ohio, and Missouri.

The natural distribution of the species is evidently in the South Atlantic and Gulf States and in part of the Mississippi and Ohio River Valleys, from which it has been temporarily introduced into other States.

This beetle infests the seasoned sapwood of commercial products made from persimmon, hickory, ash, oak and bamboo; it also lives in the dead wood of natural growth of osage orange, sassafras, and fig.

Adults of the velvety Lyctus are active from the middle of March till the last of August at Washington,

*Farmer's Bulletin, No. 778, Dept. of Agriculture.

[1] The Lyctus beetles which are responsible for the principal losses belong to four species, viz., *Lyctus linearis* Goeze, *L. planicollis* Le Conte, *L. parallelopipedus* Melsheimer, and *L. canicollis* Le Conte.

[2] A large female of *Lyctus planicollis* Lec., about one-fourth inch in length, that was dissected contained ovaries as two separate, elongate ovate clusters one-tenth inch in length, one of which was about one-third the size of the other. These ovaries took up most of the space of the abdomen. The eggs were arranged in rows so as to have the appearance of being braided. The mature ovules, or fully formed eggs, are pointed at one end and rounded at the other, with the rudimentary strand present at the rounded end. The egg surface is apparently granular. At least 40 eggs were in the larger mass.

[3] *Lyctus linearis* Goeze.

[4] *Lyctus planicollis* Lec.

[5] *Lyctus parallelopipedus* Melsh.

D. C. General emergence occurs from June to the last of July.

THE WESTERN LYCTUS[2]

The western Lyctus is a rusty red-brown, slender beetle, somewhat flattened and elongate, and from about one-seventh to about one-fifth inch in length; the punctures on the wing covers are very fine and placed in more or less distinct double rows.

This species is recorded from California in commercial products, seasoned orange wood and hickory, tanbark oak and cordwood of live oak.

Adults of this species are active from April till the middle of September.

Second-growth white wood or sapwood of the finest quality of hard woods, especially hickory, ash and oak, which has been stored or piled in one place for two or three years or longer is especially liable to damage by Lyctus beetles. This is particularly the case if the material has not been handled or moved and if the old stock is allowed to accumulate. Refuse and useless sapwood material and infested stock piled about the sheds or yards, sapwood piling sticks, etc., are sources of infestation. If the different species of hard woods are not placed in separate piles, the species of woods not so liable to attack often become infested.

Material of species other than hickory, ash and oak is less liable to attack. Sapwood seasoned for less than eight to ten months will not be attacked, and *heartwood is never attacked.*[3]

INSECT ENEMIES OF LYCTUS BEETLES

There are many insect enemies of powder-post beetles. Among the beetles, species of the family Cleridae are often beneficial in checking the multiplication of Lyctus beetles, the larvæ preying on the Lyctus larvæ and the adults preying on the Lyctus adults. Other beetles which commonly prey upon the powder-post beetles belong to two other families.[4]

Many species of small, four-winged, wasplike parasites have the Lyctus beetles as their hosts. The emergence or exit holes of the adult parasites are much smaller than those made by the beetles, but are often mistaken for those made by young Lyctus larvæ.

In general, these insect enemies, although beneficial, can not be depended upon to keep the destructive beetles under control, and therefore usually can be disregarded when practical control measures are being instituted.

The methods of combating this class of insects and of preventing losses from their ravages come under two primary heads: (1) The destruction of the insects, or remedies, and (2) prevention of attack.

REMEDIES

Infested material, including infested sap edges of lumber, etc., and all refuse sapwood in which the insects might breed should be eliminated by sorting it out and disposing of it by burning or otherwise. All material showing the slightest evidence of powder-post damage should be discarded and destroyed, except possibly such articles as may be tested for required strength and found to be of sufficient value for retention after treatment.

Material slightly infested and damaged should be treated with kerosene oil, after which it should be kept in quarantine a sufficient length of time to determine whether a second treatment is required.

All partially damaged material, such as the sap edges of lumber and parts of other material too valuable to be destroyed, should, when practical, have the damaged and infested parts cut away and burned.

The work should be done between October and the first of March in storehouses, and before the first of April in the open. If this is thoroughly done, and, by annual inspection thereafter, infested material is disposed of as soon as found, there will soon be no trouble from this source, unless there is a continued introduction in lumber and material received from other yards and localities where methods of control are neglected. To avoid this, all material should be carefully inspected before shipment, or at least before it is placed in the yards or storehouses.

Where it is not practicable to remove the infested parts, or in case of the more valuable stock, the wood should be subjected to methods of treatment for the destruction of the insects between October and the first of March. Of the following remedies, that most suitable in each case should be selected, remembering that the treatment must not be detrimental to the wood for subsequent uses.

(1) Liberal applications of pure kerosene oil with a brush, or immersion of infested wood in vats of kerosene The only objection to kerosene is the fire risk. However, kerosene soon evaporates, so that the treated material is not long near the danger point. Kerosene oil does not affect the application of shellac or varnish; the only effect on finishing is to make it more difficult to stain kerosene-treated sapwood to match the rest.

(2) Mixtures of 3 parts creosote and 1 part kerosene oil; 3 parts kerosene oil and 1 part creosote (to obtain a deeper penetration); and 1 part creosote and 3 parts naphtha have been used successfully. The wood should be dipped in vats of preservative, preferably heated by coils of steam pipe, or the preservative may be applied hot with a brush. *Of course, mixtures containing kerosene oil should not be heated over a direct fire.*

(3) Thorough steaming of the infested wood in a tight room or under pressure. Steaming under pressure weakens and discolors the wood and should not be applied to wood to be used for fine finish or where strength is essential.

(4) Subjecting seasoned wood to temperatures over 200° F. in dry kilns.

(5) Fumigation of infested wood in tightly closed drying rooms with the fumes of sulphur at the time of the emergence of the adult beetles. This has been recommended for killing the beetles and preventing egg laying.

The objection to treating infested material lies in the fact that if it is once infested it may be damaged beyond repair and not safe for future use. A break might result in a serious accident and reflect on the reputation of the manufacturer or distributor.

PREVENTION OF DAMAGE

By the adoption of the following system of inspection, classification, and the proper disposal of the seasoned sapwood of hard wood stock, loss by powder-post beetles can be prevented:

(1) Inspect material in yards and storehouses annually, especially stock two or more years old, preferably in November and February. Then (a) sort out and burn material showing evidence of powder-post attack and (b) burn all useless sapwood material.

(2) Classify all dry or seasoned hardwood stock as (a) hickory, ash, oak, etc.; (b) heartwood, pure sapwood, and part sapwood; and (c) according to age, that is, the number of years it has been seasoned.

(3) Utilize or sell oldest stock on hand first. Prevent the accumulation of old stock; in other words, keep the stock moving.

(4) Prevent the accumulation of refuse material in which the insects can breed.

(5) Use only heartwood piling sticks in lumber piles.

(6) Inspect all new stock to prevent the introduction into lumber yards and storehouses of powder-posted material.

(7) If the beetles have not been eliminated from the yards and storehouses, stock that has been seasoned longer than eight months, and which is to be held in storage, may be rendered immune by treating it with two coats of boiled linseed oil applied hot, or it may be immersed in vats of hot oil. The boiled oil will dry more rapidly than the raw linseed oil, especially if kerosene is added to the hot oil. The wood should be treated between October and the 1st of March.

Linseed oil has an advantage over other substances in that it can also be profitably applied to unseasoned timber, since it will prevent checking in seasoning. This oil stains the wood slightly yellow. In case of wagon stock, however, it can be used without prejudice to the trade and is an effective preventive.

Creosotes can be effectively used in case of stock to which the brown stain will not be detrimental. The wood should be dipped in vats of hot creosote, or the preservative should be applied hot with a brush.

In case of finished products or more valuable material, any substance which closes the pores of the wood may be effectively applied. For example, paraffin wax, varnish, etc., effectively close the pores of the wood and prevent the beetles from depositing the eggs, which are laid in these pores. Thus the sapwood portions of backs and interior surfaces of cabinet work, inside finish, and furniture, etc., should also be treated to prevent attack.

In conclusion it may be stated that while there are a number of effective chemical treatments to prevent attack, and to kill the insects after they get into the wood, the great objection to all of them is the great and recurring expense of treating material that never would be attacked if, by the proper methods of management, the premises were kept free from the pest.

[2] *Lyctus caricollis* Lec.

[3] Exhaustive strength tests conducted by the Forest Service show that the heaviest, and consequently the strongest, hickory averages below 10 rings per inch in rate of growth, and that, weight for weight, red hickory (heartwood) is as strong as white hickory (sapwood).

[4] Histeridae and Cucujidae.

Telegraph Poles in Africa

WHITE ants abound in practically all the tropical Colonies, and while it is usual in such countries to find an indigenous wood which is more or less immune from their attacks, like the teak-wood of Burmah, the cedar of British East Africa, and the sneeze-wood of South Africa it is not always suitable for use as telegraph poles. In several of these Colonies there are large indigenous forests where the growth is so dense and heavy that it is a very costly matter to cut a clearing through it when a new line has to be erected. The practice in Nigeria, which is probably unique, is to clear a space of from 100 to 300 feet in width so that the wires may be well clear of the branches of trees. The cost of maintaining these clearings is very heavy. A peculiarity of these forests is that there is no uniformity either of size or of shape in the trees. Many will be over 200 feet in height by eight or more feet in diameter. Below these there are trees of every other conceivable height and shape, and the whole forest is interlaced with an impenetrable mass of climbing and twisting growth. To obtain any considerable number of poles of anything like uniform size and length would be impossible unless a very large area of forest were cleared, and the cost of this would be prohibitive. South Africa is not what may be termed a timber country, although there are forests of indigenous trees here and there. Among these the "sneeze-wood" is the only one that will withstand the ravages of the white ant for any length of time, but even this wood is not free from attack. This ant will drive its tunnels from the bottom of the pole to the top, through the outer rings of the wood, but as it approaches the core of the tree it will stop, because the core is too hard for it to penetrate. The core of the "sneeze-wood" is almost as hard as iron while yet as flexible as whalebone, and the author has heard of only rare cases in which the ant has been able to eat into it.

The author has known poles which were originally six or seven inches at the bottom tapering to about four inches at the top reduced in this way to an average of about three inches. The pole became so slender that even the weight of a ladder leaning against it would cause it to bend over like a whipstick. They were also liable to be destroyed by grass fires in the dry winter season. It was the rule to clear the ground of all grass and undergrowth for several feet around each pole, with hoes, so that a fire would not actually reach the pole. Many poles were burnt off several feet above the ground line by burning embers, carried by the wind into the cracks and crevices in the poles and fanned into flame there by the wind. The author has also known oak arms on iron poles to be destroyed in the same way. These sneeze-wood poles were of rough appearance, crooked and gnarled, but they served their purpose well in the construction of the lines that were built throughout the country in the early days. The author does not think any method of treating these poles, such as the injection of creosote or other substances obnoxious to the white ant, was ever tried, but even if this were effective so far as the ant is concerned, there would still be the liability to destruction by grass fire. The poles were not suitable either in height or strength to carry more than a few wires, and with the gradual opening up of the country they were replaced with tubular iron taper poles imported from England. In recent years wood poles from eucalyptus trees grown in Government plantations in the Cape Province have been tried experimentally on certain lines in the neighborhood of the plantations, but the experience so far has not been favorable.

In British East Africa and Uganda there is a "live" pole in use which is perhaps unique in its way. Some years ago a temporary line was erected with poles got from a species of natural wild fig-tree, and these poles, when planted, unexpectedly took root and became trees. These poles, although not absolutely immune from the attacks of white ants or decay, were found to stand much better than ordinary "dead" wood poles, which either rotted or were destroyed by white ants in a very short time after their erection. Benefiting by this experience, the administration built about 1,000 miles of line with this type of pole. They were cheap and they have served their purpose well in the development of the country during a period when funds were limited. They have their disadvantages, however. They are liable to become top-heavy and blow over during storms. The leaf growth is also a source of trouble, as if it is not very carefully watched it leads to serious loss of current in wet weather. This is so much the case that most of the lines on these poles have to be worked by vibrator instead of the ordinary Morse system. With improved financial conditions these colonies are now using tubular iron poles.

—From a paper on Colonial Telegraphs read by R. W. Weightman before the Institution of Electrical Engineers (London).

Uses of Balangot in the Philippines.—Balangot, a common sedge that grows wild in the marshes of Pampagna, is being put to a number of uses, many articles being made from it in the native schools of the district. Among these are cheap and excellent sandals and door mats. It is also made into cushions for the seats of automobiles.

Anomalies in the Animal World—Part II

Flying Mammals and Flying Rodents

By R. W. Shufeldt

FLYING LEMURS

FLYING LEMURS are now assigned by naturalists to two different genera of the *Galeopteridæ*. Those belonging to the Malayan fauna are restricted to the genus *Galeopterus*, while those of the Philippines are contained in the genus *Cynocephalus*, the best known and longest recognized species being the common Flying Lemur (*C. volans*).[1] These flying lemurs are found in the Malay Peninsula, the Philippine Islands, and in the forests of Sumatra and Borneo. Their average size is about that of an ordinary, small cat, and their most striking external anatomical feature is the skin-parachute that stretches not only between the limbs, but is continued in front to include the head, while posteriorly it takes in the entire tail (see Figs. 10-13).

Fig. 11. Cobego or Flying Lemur, front view, greatly reduced. Exhibits outstretched "parachute" and young. After W. Saville-Kent

These animals live among the trees, flying from one to the other, as occasion demands, by the aid of the aforesaid spreading, dermal parachute. in other words, they perform *flying leaps*—a very different matter from the varied and sustained flight of the bats.

Several vernacular names have been bestowed upon these mammals, one of the most widely used being that of "Cobego," while in the Philippines and elsewhere it is known as the "Colugo"; "Kabung" is one of the old, native names for a Flying Lemur.

When Mr. Richard C. McGregor sent me specimens of flying lemurs a few years ago, upon which an account of their osteology was based by me, he wrote me that "these were collected near Guindulman, Bohol, where the species is fairly common. A considerable number are killed by the natives, but I did not learn that the fur was used by them. In Cebu there were between twenty and thirty skins of this species for sale in the stores; they came from Bohol, of course, as the species is unknown in Cebu. It is also found in Mindanao, Samar and Basilan.

"This animal seems to be strictly arboreal, and to feed exclusively on the leaves of trees. It is an animal difficult to see, as whenever it suspects danger it remains perfectly quiet and hugs a branch. Its colors are quite protective. When moving in a tree it is very cautious, and seems to glide rather than to move like a squirrel or other small mammal; in fact, its movements impressed me as being very snake-like. The native name is 'Ca-guán.'

"The color of the pelage, even of specimens from one locality, varies greatly, running from seal brown to light gray, and from unspotted to thickly spotted with gray."

As in the case of the bats, these flying lemurs have but one or two (usually one?) young at a time, and they nurse them at the breasts, as noted in the last Part (Part I). The young are devoid of hair when born, and remain so for a while thereafter. We have yet much to learn about their habits—a part of their natural history which was much mixed up by the older naturalists. It was claimed by them to feed upon fruits, insects and small birds, which statement is contradicted by Mr. McGregor in his letter given above. In writing about them, Swainson said: "To give its most striking characteristics in a few words, it is a lemur, with the limbs connected by a bat-like membrane, or, in other words, surrounded by a thin skin which they support, as the framework of an umbrella supports its covering. By this singular structure the animal is supported in the air; yet without the power, like the bats, of sustaining a continued flight." Another writer, continuing these remarks, states that "like the flying squirrel, it can sail a great distance from one tree to another, spreading out

Fig. 10. Female Flying Lemur with young; much reduced. After Gervais

its membrane to serve as a parachute, but not as wings. It manifests great skill and energy in dropping from the upper limbs of the trees upon its prey below. It makes great havoc among the colibris, and other small birds, which throng the forests [!] Like the bats, it is nocturnal and insectivorous. The mammæ are pectoral. This animal sleeps suspended by the hind legs, with its head downward. [Fig. 13.]

"The female produces one young at a time. This she places in a soft nest for four or five days; then it clings to her breast, and accompanies her in all her wanderings,

Fig. 13. Cobego asleep, holding on to limb with its four feet. After W. Saville-Kent

till it is able to take care of itself." This writer seems to include the "colibris," or small birds he mentions, among the insects.

When asleep and suspended by its four feet it is said that its enemies often take it for a fruit, which it resembles in size and color. This statement may be taken for what it is worth, and yet it may be entirely true.

In his article on the Mammalia, in the *Encyclopædia Britannica*, Flower remarks of these animals that "they feed chiefly on the leaves of trees, and probably also on insects. Their habits are nocturnal, and during the daytime they cling to the trunks of limbs of trees, head downwards, in a state of repose. [See Fig. 13; this statement is undoubtedly incorrect.] With the approach of night, their season of activity commences, when they

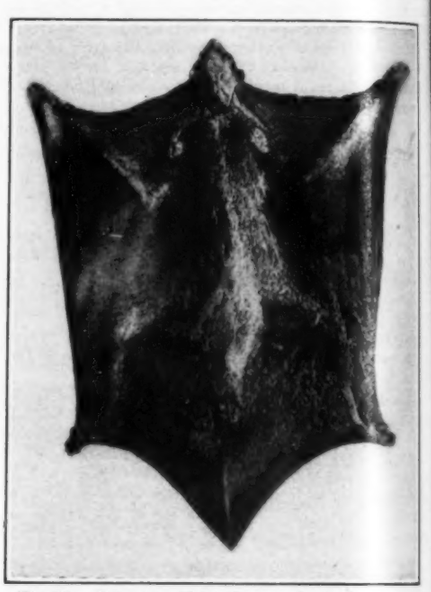


Fig. 12. Cobego or Flying Lemur; back view, seen directly from above. Reduced. After W. Saville-Kent

may be occasionally seen gliding from tree to tree on their cutaneous parachute, and they have been noticed as capable of traversing in this way a space of 70 yards, with a descent of only about one in five."

The older zoologists all classified these animals with the true bats; while in my paper, cited above, it is shown that they are aberrant insectivores. Anatomically they have but slight relationships with the lemurs.

Professor Flower, in his above cited article, presents us with exceilent figures of the feet of *Galeopithecus* these are seen to be webbed, in the case of both fore and hind feet, clear to the base of the claws, which latter are much curved and sharp-pointed.

FLYING PHALANGERS. FLYING SQUIRRELS

There are some ten genera created to contain upwards of forty species of the mammals known as Phalangers, the assemblage being grouped in the family *Phalangistidæ* of systematic zoologists. For the most part they inhabit some of the East Indies, Australia and Tasmania, many of the species being of wonderful beauty, presenting interesting life histories, and, in most instances, morphological peculiarities.

Phalangers are marsupial animals; indeed, one or more of them in Australia are known as "opossums"—all the opossums, including our well-known United States form, being marsupials. They range in size all the way from that of a mouse to species as large as a big cat. But in this place space will only be devoted to a special section of them: those possessing a flying membrane formed by a layer (double) of the skin, stretched in parachute-fashion on either side of the body between the fore and hind limbs. Phalangers thus endowed have non-prehensile tails; other members of the family possess prehensile tails, but they lack the parachutal membrane.

A number of the Phalangers have been known to naturalists for at least three centuries, while others were not described until a much later date. As a group, Phalangers possess wonderful, woolly coats, with very

[1] Shufeldt, R. W. "The Skeleton in the Flying Lemurs, *Galeopteridæ*." *The Philippine Journal of Science*, Bureau of Science, Manila, P. I., Vol. VI., Nos. 3 and 4, Sect. D, 1911, 2 Parts, pp. 139-165, 8 Plates. PP 185-211, Pls. 3-5. Full account of the osteology of these animals given, based on author's collection and that of the U. S. National Museum.

thick woolly tails of extraordinary beauty; these are sometimes prehensile, as just stated.

They have no nails on their big toes, and these are opposable, as any good observer of animals knows to be the case in our common Virginia opossum. During the day Phalangers are stupid little things—as is the case with most nocturnal creatures; but when night comes they change entirely, and become as lively as you please. Some of them make very interesting little pets, and at this writing probably hundreds of them are thus kept in different parts of the world. It is said that they will occasionally feed upon a small bird or even mammal; but as a rule they subsist in nature upon leaves, on blossoms of shrubs and trees and on different kinds of fruit, though some are insectivorous.

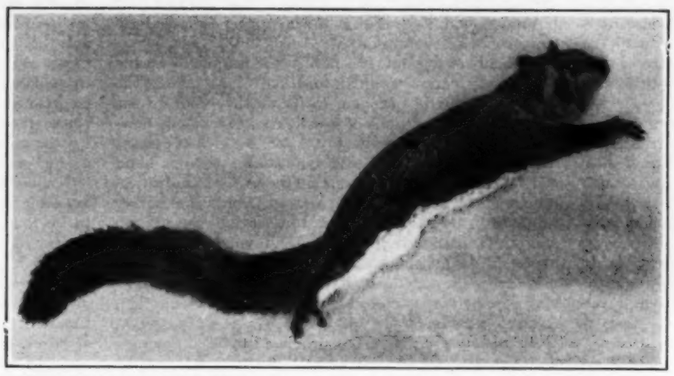


Fig. 14. Lesser Flying-Phalanger. Its appearance in the air when making one of its extraordinary leaps. Illustration given by W. Saville-Kent

It is in the big, black Taguan Flying-Phalanger of New South Wales, Australia (*Petaurista volans*), that we begin to see a serviceable flying-membrane developed. Here the parachute only extends from just below the knee, forward to the elbow on either side. It has large, hairy ears and formidable claws. In size it about equals the large flying squirrels we meet with in India, and it is a very striking looking animal with its big, round and bushy tail, which latter is non-prehensile. As to its habits, they agree pretty well with those of other flying-phalangers, of which mention will be made here.

There is another genus of flying-phalangers, which is known as *Petaurus*, and which ranges from New Ireland to South Australia, the best-known species being the Yellow-billed Flying Phalanger (*P. australis*). The eminent Australian naturalist, John Gould, wrote of it as follows: "This animal is common in all the brushes of New South Wales, particularly those which stretch along the coast from Post Philip to Moreton Bay. In those vast forests, trees of one kind or another are perpetually flowering, and thus offer a never-failing supply of the blossoms upon which it feeds; the flowers of the various kinds of gums, some of which are of great magnitude, are the principal favorites. Like the rest of the genus it is nocturnal in its habits, dwelling in holes and in the spouts of the larger branches during the day, and displaying the greatest activity at night while running over the small leafy branches, in search of insects and the honey of the newly opened blossoms. Its structure being ill adapted for terrestrial habits it seldom descends to the ground except for the purpose of passing to a tree too distant to be attained by springing from the one it wishes to leave. The tops of the trees are traversed by this animal with as much ease as is the most level ground by such as are destined for terra firma. If chased, or forced to flight, it ascends to the highest branch and performs the most enormous leaps, sweeping from tree to tree with wonderful address; a slight elevation gives its body an impetus which, with the expansion of its membrane, enables it to pass to a considerable distance, always ascending a little at the extremity of the leap; by this ascent the animal is prevented from receiving the shock which it would otherwise sustain."

Another species in this genus, the Squirrel Flying-Phalanger, *P. sciureus*, is, in many respects, one of the most beautiful of all mammals known.

In the exquisite little Pigmy Flying-Phalanger, also of South and Eastern Australia, the membrane is reduced in width along its middle third between the limbs, while its flight is quite perfect; indeed, the leaps it sometimes makes are truly extraordinary. The descendants of this species, which is smaller than the common house mouse, may, in the remote future, have the membrane increased through natural selection. These phalangers live on honey and insects, the honey being extracted from the flowers of trees; in captivity they make the most charming little pets. The tail in this form, says Saville-Kent, "is also adapted for aerial flotation, the long hairs that grow upon this appendage being arranged in two parallel lines like the vanes of a feather." Specimens kept alive by this well-known naturalist did not exceed two and a half inches in length of body.

Many Australians speak of these numerous species of flying phalangers as "Flying-squirrels"; and, as a matter of fact, in a few instances they certainly do very much resemble the well-known little rodents bearing that name in this country. In principle, their flight, too, is identical if "flight" it may be termed.

Sugar-squirrels, of the species of Flying-Phalanger found in the forests of the southeastern districts of Australia, make, as stated above, most interesting little pets. Speaking of these, Mr. Saville-Kent informs us that they are for the most part "addicted to sleep and impatient at being disturbed during the day; towards sun-down they wake up and are full of frolic. One such example was the writer's traveling companion for a considerable interval in Western Australia. While remaining packed conveniently away in a small box throughout the day, it was accustomed to enjoy the liberty of whatever apartment its owner occupied in the evening and throughout the night, returning of its own accord to its sleeping-box with the approach of dawn.

Fig. 15. Squirrel-like Flying-Phalanger of Victoria; reduced. After W. Saville-Kent

On one exceptional occasion, however, Master Tiny, as this individual was named, was missing one morning from his accustomed crib, and a prolonged search and examination of every corner and article of furniture that could afford shelter failed to recover him. That the little creature was lost through some one unwittingly leaving the door of the apartment open, permitting its escape, was the only and much deplored conclusion

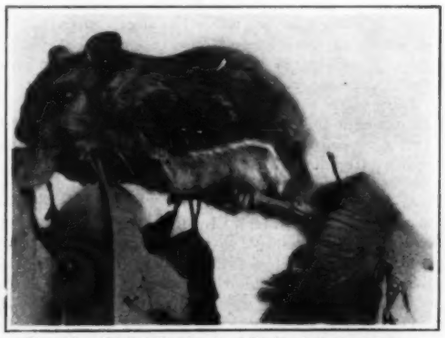


Fig. 16. Flying-Squirrel on limb of chestnut tree; much reduced. From life by the author

that could be arrived at. Towards evening, however, there was a slight rustle close at hand, and Master Tiny was discovering emerging, like Minerva from the head of Jupiter, from the top of one of the old-fashioned dogs that decorated the hotel room mantelpiece. The ornament, seemingly intact from the front, had the back of the head battered in. Through the resulting crevice the little animal had managed to squeeze itself, having come to the conclusion, doubtless, that this newly chosen retreat more nearly resembled the cavernous shelter of its native tree-spout than its accustomed artificially constructed box. This singular domicile Master Tiny was permitted to monopolize for the remainder of his sojourn at that hostelry. One of the favorite diversions of this little phalanger during the evenings was to climb up the curtain and cornice of the room he occupied, and thence hurl himself through the air with outespread parachute to the writer at the opposite end. The apartment happening to be the commercial room at the hotel, some thirty feet in length, it gave him good scope for exercising his characteristic flying leaps. The attitude invariably maintained during these flights is aptly illustrated in the accompanying photograp [Fig. 14]; the body is never poised with the head inclined downwards, as is commonly depicted in artist's fancy sketches of the animal contained in popular natural histories. A friend of the writer's in Tasmania, who kept one of these flying-phalangers as a household pet, was accustomed to leave a crevice of the window open at night, so that the little fellow could go in and out as he liked. After the manner of most pets, however, a day arrived upon which its box was found vacant, a marauding cat or other disaster having apparently encompassed its untimely end."

As to the larger flying-phalangers—animals that scale through the air by means of their parachute-like membranes, so well described by Mr. Saville-Kent—they are rarely kept as household pets because of their cross nature and general untamableness. As a rule—and there have been but few exceptions to it—they scratch and bite on the slightest provocation, and when this is the case there are few who care to keep them.

Examples of the albino flying-phalangers are not so very uncommon, especially among the Tasmanian forms—a fact which pertains to other representatives of her fauna, even to include the Emu found on the island.

Passing from these most interesting flying-phalangers of the East, and searching throughout the world for other mammals that may possess the power of aerial locomotion in any degree worthy of the name, we are confronted with the fact that there are no others so endowed outside the Order *Rodentia*. Within the *Rodentia* they belong to two very distinct families, and their power to sail through the air for many yards at a leap, in a gradual downward course and slightly upward at its termination, rests upon the presence in them of the same kind of skin-expansion between the limbs laterally, sometiines the fore-limb and neck on either side, and the hind-limbs posteriorly, as was described above for the flying-phalangers, the flight being of precisely the same character as in the latter group of mammals. In North America, all these animals belong to the family *Petauristidæ*, being represented by some five species and numerous subspecies of the well-known little flying-squirrels (*Sciuropterus*). (Fig. 16.) Then there are the larger flying-squirrels of the Old World (*Pteromys*, etc.), of which a brief account will be given further on.

Our second family of volant rodents include the *Anomaluridæ*, of which there are some five or more species in the Ethiopian region; they are very remarkable animals, resembling large flying-squirrels in their general appearance. They also possess the lateral cutaneous expansions for their sailing flight, each expansion being supported by a *cartilaginous process* articulating at the elbow—a most noteworthy development. These animals exhibit beneath the anterior fourth of the tail a series of peculiar caudal scales, overlapping each other, which are of great use to their owner in climbing. My recollection is that there are ten of these scales, arranged in an intricate fashion; and they may, too, serve in protecting that part of the tail as the animal alights after one of its long, flying leaps. The first flying-squirrel known to European naturalists—the *Sciurus volans* of Linnæus—was a small species occurring in eastern Europe and Siberia, and there called the Palatouste. It is but six inches long, yet makes flights of 30 feet. There is a magnificent and very large flying-squirrel found in the forests of Malacca, India, and Ceylon, which the people there call the "Tanguan"; it has a body fully two feet in length, with a tail equally long, which is broad and bushy. As in the case of all flying-squirrels, the animal is strictly nocturnal in its habits, and consequently we know but little about it. Our own North American flying-squirrels stand among the least known of all mammals in this country, due to the same fact. If the

habit of being exclusively nocturnal came about from being preyed upon by other mammals, or diurnal Raptores, it has certainly accomplished its purpose to a large extent, notwithstanding the fact that some of them may fall a prey to owls and certain small mammals that hunt at night.

One of the large West African species, known as Pel's Flying-Squirrel, is briefly described by Mr. W. H. Adams. "These squirrels," says this observer, "come out of their holes in the trees some hours after sunset, and return long before daybreak. They are only visible on bright moonlight nights. The natives say they do not come out of their holes at all in stormy weather, or on very dark nights; they live on berries and fruits, being especially fond of the palm-oil nut, which they take to their nests to peel and eat. They pass from tree to tree with great rapidity, usually choosing to jump from a higher branch to a lower one, and then climbing up again to make a fresh start.

"They litter about twice a year, once in September. The young remain in the nest for about nine weeks, during which they are being fed by the old ones on such food as shoots and kernels. They do not attempt to jump, or 'fly,' till the end of that period, extending the lengths of their jumps with their growths."

Our little eastern flying-squirrel has been kept by me as a pet upon a few occasions; and further, the number of times I have seen it at large in the woods can be counted on the fingers of my two hands. One must possess an unbounded stock of patience, and be prepared to sit quietly in the forest, where these little animals are known to exist in numbers, for varying lengths of time. Several may appear a few moments after you have settled yourself to await that event, or you may have to tarry nearly to the hour of dawn before a single little chap will suddenly appear, and give you an opportunity to observe his wonderful "flying leaps," as he sails, as above described, from one tree to another.

As they select hollow tree-trunks for habitations, you can, sometimes, induce them to hustle out and "fly" to other trees by rapping with a heavy stick on the outside of the trunk. The number found in such a place may run all the way from two or three up to as many as forty. They generally choose a big, dead limb, well up in the tree, with its opening at or near the top. This opening may be a natural one, or one cut by some woodpecker or other. Of course the squirrels clean this cavity out and enlarge it; and the strange part of it is that they carry away to a distance all the chips and other evidences of their carpentry, in order to not betray the locality of their chosen home. Sometimes boys catch them in the latter places; but they are also secured in common box-traps, just as other squirrels are captured.

Stone says: "I have made them come out on dark cloudy days and watched them patiently; but their patience far exceeded mine—in fact, I am not quite sure that they did not even go to sleep clinging there against the bark, like lichens, which they so much resemble as to suggest that their clouded cream buff coloring might serve them well, imitating the fungus growth or the bark of a dead tree. Such protective copying is to be seen all through the woods. . . . But dark as it was that afternoon, it was not dark enough to suit the flying-squirrels, and I went away knowing them no better than before."

So it is to be observed that, among mammals, we find aerial locomotion of two distinct kinds: where it is absolutely perfect, as in the bats, and under full control of the animal, and where it is but a species of sailing flight from one point to another, as among the phalangers, flying-squirrels and other forms, the animal having no special control over it in mid-course other than to draw up its limbs and descend to the ground on the usual curve.

Industrial Fatigue*

In the *Engineering Supplement* for October and November last an account was given of some recent research on industrial fatigue. It was there pointed out that, interesting and laborious as the work was, some of the most important of its conclusions had been reached and acted on over thirty years ago, and that it had added little to knowledge that could be used immediately for practical purposes. What it had done to that end was to confirm and warrant on competent British authority the results of foreign and to a limited extent of British experience, and in the Reports of the Health of Munition Workers' Committee to suggest nearly eighteen months after the beginning of the war some numerical limits to the costly, inefficient, and unhealthy use that had been made of overtime. These reports were published very rapidly after the appointment of the committee, and both for their promptness and for the firm and definite advice which was given, the engineering trades among others owe sincere gratitude to the distinguished physiologists and medical men who appear to have been responsible for the work.

Probably at this date it is hardly worth while to discuss further any variations in the method of attacking the grave problems in question, so far as they concern the production of munitions of war. These problems, however, are part of a permanent question to which at present no answer can be given—the question on the one hand of how the fatigue which occurs necessarily in industrial processes can be controlled so as to permit the worker to produce the most that he can in continuous working, and on the other hand (though it is involved essentially in the first condition) of how much fatigue can be removed completely in a given period of rest. Fatigue may here be taken to be energy lost through occupation, energy denoting power to do work.

Before any solution of this problem can be of practical use it must take account of such circumstances of the man to whom it is to be applied as affect the rates at which he becomes fatigued and recovers. The fatigue developed in any period of work is generally understood to depend principally, as was first suggested by Abbè, on the time occupied, the quantity produced, and the speed of manipulation, taking all other conditions to be constant. In practice, however, conditions are not constant. They vary, for instance, from man to man, and even in the same man at different times, according to his susceptibility to the several influences in .play; also from works to works, according to the effect of the works' conditions on the strain involved in the job. The rate of recovery, or its extent in a given rest-period, depends again necessarily on the way and conditions in which the rest is taken.

Not the least among the reasons for which the study of fatigue is essential to industry at the present time is that it brings out relations between work and its conditions that otherwise are apt to escape attention or be depreciated. When fatigue is not considered, expressly or by implication, an employer—or for that matter a man—may often be satisfied if given conditions, say, of lighting or heating, are such as merely to allow the work to be done, but may overlook altogether whether they help or hinder it. This point of view is particularly likely to be taken when the workman has, or is supposed to have, a good part of his energy "up his sleeve," and the question both for his employer and for him is how much of it he is going to use. In such circumstances, the employer may, for example, quite reasonably see in a cold shop the means of inducing men to keep themselves warm by working a little harder than they otherwise would. Today, however, it is common ground that in work after the war either all the energy men have during their working hours will have to be spent on their work, less so much as must be retained to allow proper use to be made of the rest period, or else that British industry will rapidly go to pieces. With men so working, conditions which cause or increase fatigue cannot be remedied by drawing on a surplus of energy, for energy by hypothesis is no longer being hoarded. If such conditions are permitted, their cost comes not on a surplus but on the output and the energy that should be reserved for rest; and even from the strictly economical aspect, regulation of fatigue is as material to the cost and extent of production as the control of feeds and speeds to a machine job.

Both the known circumstances and the results that have recently been published show that homogeneous material—the similar men working on similar jobs in like conditions—cannot easily be found in sufficient numbers and with the necessary variations of the factor under study to give assured conclusions as to fatigue, except in terms that are either too closely restricted to the particular conditions of observation to be applied generally, or are not precise enough to give any substantial extension of existing knowledge. This difficulty is the greater because uncertainty and difference of opinion seem to exist as to how fatigue itself can be directly measured; and even among physiologists the balance of opinion seems to be that more accurate results can be obtained indirectly from figures, such as those of output, which are affected by fatigue among other factors, than directly by the various methods of experimental psychology, as yet a young and tentative science. No doubt the difficulty of getting precise results by the microscopic or statistical study of workers in groups has its effect in retarding the discovery of a convenient test for fatigue which might be hoped from the microscopic or intimate study of individuals. But even if such a test were avaliable, its use would not overcome the difficulties created by the number of factors involved; and such difficulties are the graver in this problem than in many others because no one factor can be said with certainty to be always the most important.

For the time being, at least, it seems hopeless to obtain a general formula for the hours of work applicable to each class of operation, in whatever conditions the work is done. But for the future of industry this is not the most important problem; and conclusions in regard to fatigue that were assured only in certain definite circumstances would be of the utmost value if in other respects those circumstances were known to produce the most efficient output—that is, the maximum output for the energy spent, or, alternatively, per worker and unit of plant.

The material for beginning such an investigation is not available in sufficient quantity in this country; but it is to be found in the United States. There, in a large variety of industries, establishments have been running for many years under far more definite conditions and with far more than average efficiency, and under their methods results have been recorded in much more intimate detail than has been usual elsewhere. The study of these records would disclose much that otherwise could be sought only by a process of trial and error far longer, more costly, and less promising of a final result. It is now recognized in this country that, as was known thirty years ago in the United States, the daily period of rest is not the only possible means of abating fatigue and conserving energy. In many instances results far transcending those of variations in working hours have been obtained by intercalating short rests in the periods of work itself. To determine the best length and incidence of such pauses *de novo* would be an interminable work, when done would have to await prolonged experience before the results could be accepted as safe and certain. This is only one example of the data which are already available in American experience as guides for any research that may be undertaken over here.

The shortest and most hopeful method of attacking the problem of industrial fatigue seems to emerge distinctly from these facts. In each industry in which works have been conducted for a sufficient time under conditions strictly controlled with a view to efficient production, the records of such works, whether they are in this country or in the United States, should be studied minutely, as happily would be possible through the good will and courtesy that characterize American manufacturers. Such a study calls for the services no less of men experienced in the arts practised than for those of the physiologists and medical men by whom alone the effects of fatigue can be finally assessed. Such joint inquiries would give a large number of results on the relation of output to fatigue, defining periods of rest both within and outside of working hours by which fatigue had been avoided, energy conserved, and output increased. These results would be warranted by actual prolonged experience, and on the strength of them it should be possible to define and obtain experimental variations of conditions of work in factories at home by which their validity could be tested. Such variations would have to be made no faster than experience had shown to be necessary to the best result, and many controllable factors of output, notably that of incentive, would have to be made similar to those that had been successful in the original experience. From such studies and experiment results true for all establishments in the trade concerned which were run under similar conditions might be confidently expected, and a high probability would remain that even more general conclusions, possibly enlarging the assistance to be obtained from methods of individual test, might be reached incidentally. At the least a body of knowledge would be made available for the use of those works to which efficient production is the first consideration; and though such an achievement is less ambitious than the attempt to attain results applicable to all works, it must be remembered that in the long run—which is not likely to be so very long—the salvation of industry and the nation will be found to rest with the works which would benefit immediately by the knowledge now proposed to be sought.

Such an inquiry would coördinate statistical science and experimental psychology to an end which each has hitherto been unable to attain. The sciences that teach how human energy can best be utilized are younger and more feeble than those that describe the materials in which men work. But already they have taught the more enlightened of American works how to increase their production, raise their wages, and give the lives of their workmen a higher value than they have had before. A great Department has been instituted to help individual arts by scientific and industrial research. Industry cannot be too grateful for the help this Department is giving and proposing to give in promoting the better use of materials. But industry and the country and, above all, its individual workers have quite literally more to gain by increased knowledge of how best to use human energy than by any likely improvement in industrial processes. The inquiry that is here proposed would be impossible without funds and facilities such as this Department possesses.

*Engineering Supplement of the London Times.

The Romance of Radium*

As in diplomatic and commercial spheres of activity, so also in the field of scientific research, Germany has, particularly of recent years, proved an increasingly formidable rival to this country. And nowhere perhaps has this been so markedly exhibited as in the spade-work necessary to discover and exploit the curative properties of radium. It should be our business, when normal conditions are reached, to extend our operations in this very important matter.

The story of radium and its discovery is tinged with the spirit of romance. It is a story unequaled in the world's history as radium stands unequaled at present among the world's metals. Looking back, from the laboratory of Prof. Curie, down a long vista of years one can trace the gradual evolution of a scientific certainty out of the half-formed and crude beliefs of the Middle Ages.

First, working from that period in our history, we find the alchemist, an object of considerable persecution, and yet obstinately pursuing his objective with a remarkable faith, busily striving to transmute the elements. His motive was not perhaps of the loftiest, since it confined itself to a realization of profit by turning the baser metals into the nobler. Yet that motive represented the foundation upon which was built presently the discovery of radium.

Then we arrive at the advent of chemistry as an ordered science, the foundation stones of which were the immutable and completely independent chemical elements. The orthodox followers of chemistry did not press to experiment the notion of transmuting the elements, and, had these had their way, perhaps the struggles of the alchemists might have so been brought to a cul-de-sac. There were, however, some who were not unmindful of the alchemists' dream and the hypotheses of Prout, which assumed without absolute proof a primordial substance common to all elements. And these were bold enough to speculate on the problem of the fundamental nature of matter, and to seek an answer to this riddle which has excited interest and taxed ingenuity since the beginning of civilization. But, in most instances, ordered experiment was dominated by idle speculation; and so it came that only within the last decade or so, true transmutation has been established as an experimental fact. Even in the early nineties, it was not infrequently maintained that, the science of physics having put its house in order, further advances could only be looked for along the lines of precise measurement. Such pessimism was, nevertheless, soon to be utterly confounded by a sequence of discoveries such as the boldest imagination had never projected. And indeed no reflecting mind can even now survey the present state of physics without realizing that we have not yet extracted a tithe of the potency which lies in the shadowy boundaries of the unknown.

The first stepping-stone to the "new physics" was the discovery of "electrons" by Sir J. J. Thomson at Cambridge in 1897. The discovery resulted in the present accepted theory of the constitution of matter. It paved the way for a ready recognition of the amazing properties of the radioactive elements, then on the point of discovery; and it led to the establishment of a new school of physics which accepted as a creed the theory of the transmutation of the elements. It can be readily understood that the placid existence of chemistry was rudely startled; but, as events proved, the atomic foundation-stones, though threatened, were left undisturbed. What happened was that a fresh story had been added, though not, as was at first anticipated, at the expense of the stability of the structure.

Meantime, in 1895, Prof. Röntgen, working in Bavaria, had discovered the X-rays, and achieved world-wide fame. In 1896, only two months later, Becquerel showed in Paris that uranium salts were spontaneously "radioactive" and, like X-rays, could affect a photographic plate even through a sheet of paper or metal. This was followed presently by the crowning achievement of Prof. and Mme. Curie in Paris. They perceived from their experiments that the natural activity of the uranium compounds was largely due to the presence of a trace of some other substance. They set to work on a large quantity—more than a ton—of uranium residues; and, by an almost endless series of precipitations and crystallizations, they finally succeeded in isolating a few milligrammes of a salt of a new element of intense activity. In short, they had discovered radium.

A ton of material contains roughly a thousand million milligrammes; and the laborious work entailed will stand for all time as a monument to the skill and patience which the Curies brought to bear upon a problem calling for the highest technical skill. Since then, radium has been obtained as a shining white metal; but the name in its everyday use always implies the salts of radium. These are white powders which, in the dark, can be seen to phosphoresce somewhat like a glow-worm.

Radium is the most amazing and revolutionary substance ever known to man. Unceasingly it gives out heat, light, electricity and X-rays, all of which is effected entirely at the expense of the energy within the atom. And the atom of radium is unstable. So that, though transmutation—the dream of the alchemist—has in the discovery of radium become a reality, it is limited by this restriction, that the change is uncontrollable by man. We cannot alter by one iota the rate at which radium disintegrates; we have as yet found no means of controlling the stupendous forces within the atom.

We now know radium to be one of a number of unstable intermediate products constituting a family tree, whose original ancestor is uranium and the last surviving member lead. The lives of these various radioactive elements range from a fraction of a second to several million years. Radium itself is the most energetic member of the family and possesses a long life. Two thousand years pass before its activity sinks to half value.

During the process of disintegration, it emits three different types of rays together with a heavy gas, or "emanation," itself radioactive. These rays are to be regarded as the outward and visible signs of the breaking up of the various items. The existence of the rays can be most readily demonstrated by their property of "ionizing," or rendering "electrically conducting" any gas through which they pass. The effect is produced by the shattering of some of the gas molecules by the radium rays: the extent of the ionization may be measured by means of an electroscope.

It was soon found that, of the three kinds of rays, one (called the alpha rays) was readily absorbed by a few sheets of paper; another (the beta rays) was only stopped by a thick sheet of metal such as lead; while a third (the gamma rays) was still more penetrating.

In the alpha rays we were introduced to a new type of atoms which possesses two features quite out of the common; the first, an electric charge (of positive sign); the other, an enormous speed—some 12,000 miles a second. The alpha rays have also proved to consist of atoms of helium, and their energy is such that their impact against a fluorescent screen is attended by a visible flash of light, as in the spinthariscope of Sir William Crookes. Such experiments provided the first means of counting individual atoms. The expulsion of the alpha ray, it should be added in conclusion, is responsible for the recoil of the remainder of the radium atom, just as a gun recoils after a shot is fired out of it.

The beta ray was early identified with the electron to be the tiniest entity of which we have knowledge. It carries a negative charge of electricity and its mass amounts to no more than about 1/1800 of that of the atom of hydrogen. The ray consists of a considerable number of groups of a variety of speeds, each group of rays moving with the same speeds. These speeds are inconceivably prodigious, the highest approaching within ½ per cent of that of light—186,000 miles a second. It requires about half an inch of lead to stop particles such as these.

The third great group of rays—the gamma rays—is identical in kind with X-rays, which have lately been shown to be an extreme form of ultra-violet light. They are almost certainly conditioned by the expulsion of the beta rays, and as a consequence the radium gives out a "spectrum" of gamma rays, each of the component parts corresponding to one of the group of beta rays. Some gamma rays are less penetrating than X-rays; but others are much more penetrating, and will in fact pass readily through six inches of lead. Against such rays it is almost impossible to obtain protection; but, happily for radium workers, such protection is unnecessary, as the rays pass through the body without any ill effect. In respect of the human body, it is only against the alpha and beta rays that one must and fortunately can guard.

The distribution of radium in the earth's crust is universal; but it no more pays to extract radium from low-grade ores than it does, for example, to separate from the sea water the gold which we know is contained in it in appreciable amounts. The labor of extraction goes up enormously as the concentration falls. Sir Ernest Rutherford has calculated that the total amount of radium in the earth's crust is of the order of 500 tons; but the majority of this is so diffusely distributed as to be inseparable by any known process.

It is upon uranium ores that the world depends for its supply of the precious metal; and, as the proportion of radium to uranium is always about one in three millions, it is sufficient for the radium prospector to establish the presence of uranium. At present radium is derived from the richer ores of uranium, such as the pitchblende found in Australia and in Cornwall. In Colorado the mineral carnotite is being successfully worked, while Portugal has sent us considerable quantities of radium extracted from the mineral autunite. The first consignment of radium from Australia came over quite recently. It is interesting, finally, in this regard, to note that the lava from Vesuvius is steadily growing more radioactive with each eruption.

It is believed, however, that not much more than one ounce of radium has yet been separated. It will therefore be recognized that it is by far the most costly substance ever yet sold in commerce. Its price indeed has been steadily advancing in consequence of the great demand, and has now reached a figure in the neighborhood of £20 a milligramme, which is at the rate of £600,000 an ounce! Such a high-priced commodity is naturally liable to many commercial abuses, and a prospective purchaser of radium should emphatically insist on its previous standardization by the National Physical Laboratory at Teddington. The British Radium Standard (which may be found described in Kaye's "X-Rays," published by Messrs. Longmans) was acquired by the laboratory in the interests of the many users of radium in this country.

It was at one time supposed that all the elements would prove to be radioactive in greater or lesser degree; but the trend of observation and experiment is that this property is confined to relatively few elements. One piece of evidence which has led to this result is to be found in Prof. Joly's work on the pleochroic halos in certain kinds of mica. These halos are seen as small colored patches under the microscope, and were long an object of mystery to the geologist. Joly has recently shown, however, that the halos are due to coloration of the mica by alpha rays expelled from a minute nucleus of radioactive matter. But, at the same time, mica is found unaltered and uncolored when associated with large amounts of other elements, a fact which seems to show that such elements do not emit ionizing rays even over geological epochs of time.

Few would have ventured to prophesy ten years ago that the new science would put an arresting finger on the estimates of the longevity of the sun and the age of the earth—subjects of exceptional interest both to the biologist and the geologist. Yet, in the earth's crust, the amount of radioactive matter and, with it, the quantity of heat spontaneously emitted far exceed that which is necessary to reconcile the older physical estimate of the earth's age—based on the earth's internal heat—with the much longer period which geologists claim as necessary.

If unshielded, radium carried in close proximity to the body for any considerable time produces an ulcer that is extremely difficult to cure. It would, on the contrary, be anticipated that an agency possessing such vital characteristics would, like X-rays, find application in the treatment of disease. And, as is well known, this has proved to be the case. It has resolved itself now chiefly into a question of improving the technique and finding the appropriate "dose." It is in this field of work that, as I have stated above, Germany has so greatly exerted herself. It is a field which is now receiving more attention in this country. Public interest is, in fact, becoming more and more focused upon the curative values of radium, especially in regard to cancer. At present it is as well to be cautious and say that radium will probably form a valuable ally in fighting cancer rather than to speak of it as a cure. It is early days to claim anything more than that the outlook is hopeful. There are, however, a number of other complaints, such as arthritis, rodent ulcers, neuralgia, diabetes, gout, sciatica, etc., in some of which treatment by radium and radium waters has worked wonders. The beneficial qualities of certain spa waters, by the way, are now attributed partly to the radium emanation they contain.

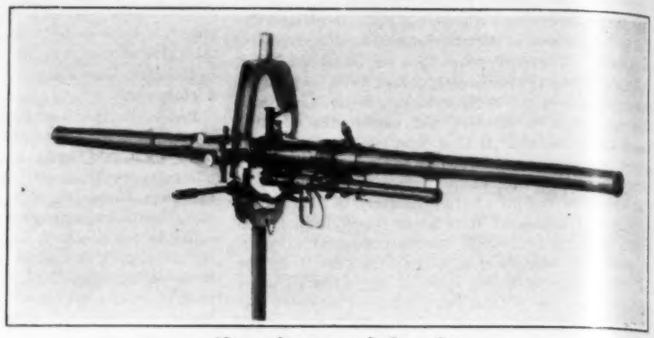
The public should, however, be cautioned against uncertified radium treatment. The warning is very necessary at the present time; and the establishment of Radium Institutes in all the large towns would give both the public and the medical profession the assistance and safeguards to which they are entitled. This is a scheme to which the Commissioners of the National Health Insurance might well give close attention.

*By G. W. C. Kaye, head of the Radium Department, National Physical Laboratory, Teddington, and in charge of the "British Radium Standard." In *Science Progress*.

Renewal of Photographic Developers

It is stated in a German patent that used or stale photographic developers can be renewed by treatment with an alkali or alkali carbonate.

2-pounder non-recoil gun in firing position



12-pounder gun ready for action

The Non-Recoil Gun

A Novel Weapon That Promises To Be An Important Factor in War

ALTHOUGH this novel type gun was invented and has been manufactured in large numbers in America, until recently little was known by the general public of this latest addition to the modern weapons of warfare.

The gun was designed primarily for use on aeroplanes where the limitations imposed as to weight and stability upon discharge at once debarred the use of the ordinary type of gun in any but the smallest sizes. In fact these limitations had restricted the armament of aircraft to machine rifles and bomb dropping devices, both of which had their defects.

The advent of the non-recoil gun has at once overcome these defects and bids fair to give the aeroplane a power undreamed of a few years ago.

The success of the guns in the smaller sizes, up to and including a 3-inch gun of 1,100 foot-seconds muzzle velocity, has been clearly demonstrated. It only remains for the development of the larger aeroplanes, a contingency of the very near future, to show the tremendous possibilities of larger and more powerful non-recoil guns. Indeed machines are being constructed in Europe at the present time that are large enough to mount a 6-inch non-recoil gun that will practically equal in power the siege guns of that size used in land operations at the present time.

For the benefit of the uninformed a brief description of the principles of operation and the essential details of construction will be given. The original conception contemplated a gun so installed that on firing it was free to fly to the rear under the reaction developed when the projectile was discharged to the front. The gun was of course lost after each shot. Further development of the idea resulted in a double length gun containing two projectiles driven, one toward the target and the other at random to the rear, by a single powder charge placed in the center of the gun. In effect the device was two guns, of equal bore and equal powder pressure placed breech to breech so that the recoil of one was just sufficient to take up that of the other. The result was complete balance of forces and total absence of the heavy shock of recoil at discharge so characteristic of all former guns. It is this force or recoil that has limited the armament of aeroplanes to machine guns and, in a few isolated cases, to one-pounder guns of low muzzle velocity.

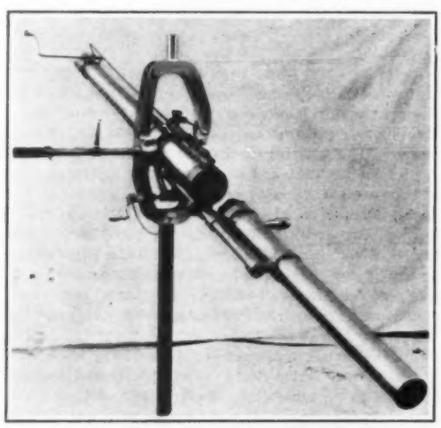
The weight of these guns due to their extreme simplicity and scientific methods of construction, and the use of special alloy steel of high elastic limit, has been reduced to a minimum. Without going into details as regards pressure stresses, etc., it may be stated that guns of this type are given a factor of safely equal to that used in other types of modern ordnance without exceeding the weight limitations imposed by mounting such guns upon aeroplanes.

One type of construction has been followed in all guns manufactured to date, and the general design is brifly as follows: The gun is composed of two separate barrels joined together by an interrupted screw thread. The front barrel, chambered at the rear end to receive the projectile and case, is rifled; the rear barrel is of uniform bore throughout and is unrifled. Its function is to provide the necessary travel for the rear projectile and when unlocked it rotates in its mounting, slides to the rear clear of the front barrel, and swings to the right and down giving unobstructed access to the breech of the front barrel for loading. This breech opening operation effected by continuous pressure on a single handle constitutes a simple and easily operated breech mechanism, comparing favorably with the latest type of quick-firing guns.

The cartridge case is of brass in outward appearance quite like that of an ordinary piece of ammunition. The projectile occupies the front end, the powder charge the midsection and the recoil charge of fine lead shot the rear end. This charge with its wads is approximately equal in weight to the front projectile, the difference being due to the difference in frictional resistance between a solid body in a rifled bore and a more or less dispersed one in a smooth bore. Upon discharge it quickly breaks up and loses its velocity a few yards from the rear muzzle, and so is not a menace to anyone behind or below.

The guns, as illustrated herewith are of extremely simple design throughout and have proved reliable under all conditions of service. The number of parts is small and the construction is relatively simple and rapid.

The foregoing applies particularly to two-pounder,



12-pounder gun opened to receive charge

six-pounder and twelve-pounder guns, ranging in weight from sixty pounds to to two hundred and ten pounds, and having an average muzzle velocity of about 1,100 feet per second. These three types of guns represent practically the entire output to date, as they were the most suitable for the type of aeroplanes in service at the beginning of the present war.

However, with the advent of larger and larger machines it has become possible to construct and to install in the immediate future guns of very much greater power that will entirely supplant bomb dropping as a phase of the aeroplane operations and will make the large battle planes a dangerous rival to the largest dreadnought afloat.

Before going into this latter function of the non-recoil gun it may be well to point out some of the limitations of bomb dropping as heretofore practiced.

It must be at once conceded that bombs of considerable weight, filled with high explosives, can be dropped from aeroplanes, and further that such bombs are capable of inflicting great damage under certain conditions. But there are three serious objections to this method; the first is lack of accuracy, the second is the fact that in order to drop the bomb in the desired spot, the aeroplane has to be approximately vertically over the point attacked. While in this position, it is exposed to fire of anti-aircraft guns. It reduces its probabilities of being hit by flying at very high altitudes, but at such high altitudes there is a corresponding increase of the inaccuracy with which it drops its bombs. The third objection is the low velocity of the falling bomb which does not give it great penetrative powers, making a battleship with its protective deck practically immune from such attacks.

The causes of inaccuracy are several in number. To begin with, the projectile starts with zero vertical velocity, and therefore requires a number of seconds in which gravity must act before it obtains a speed corresponding to its weight and the resistance of the atmosphere. While falling, the projectile has a lateral velocity due to the speed at which it was carried by the aeroplane, and in addition is acted upon by variable wind currents. Not only must these factors be taken into account and allowed for but there is an additional factor, viz., the true vertical which must be known to the aviator before dropping the bomb.

In regard to the ultimate velocity attained by dropping bombs very erroneous opinions are sometimes held, based on the fundamental formula for velocity, $V^2 = 2gh$. This formula when applied to a case of this kind is exceedingly misleading as it holds true only in a vacuum and consequently does not take into account the resistance due to the atmosphere. When high velocities are reached, the resistance of the air will increase until such resistance is equal to the weight of the bomb. In air of uniform density, the bomb after attaining this velocity will continue to descend at uniform speed since its acceleration is then zero. This maximum velocity is a function of the weight of the bomb, and a small bomb will never, within the present navigable limits of the atmosphere, attain a very high velocity. A familiar example of this is in the case of bird shot. When fired vertically upward from a shot-gun they would, in a vacuum, return to earth with the velocity with which they left the gun. But, due to the resistance of the air their return is comparatively harmless.

As an example of the above it may be stated that a 30-pound bomb approximately 4-inches diameter will never attain a velocity in excess of 1,000 feet per second, and even this velocity will be reached only after a fall of more than 30,000 feet. At the same time if such a bomb were dropped from an aeroplane, traveling 60 miles an hour, at the above height, the lateral error due to the speed of the machine will be over 4,500 feet or the bomb will actually strike nearly a mile beyond the spot aimed at. For use against ships, provided it were given sufficient strength of walls, the bomb would penetrate only about 1.5 inches of modern armor. It will therefore be seen that such an attack would be futile against battleships with their protective decks averaging from three inches to six inches thick. In such a case the destructive effect of the bomb would depend upon the explosive effect entirely, and confined as it would be to the upper decks of the ship would be very unlikely to disable the ship. The rarity of bombing operations against warships, in the present European war, would seem to bear out the above contentions.

With the foregoing in mind it will be possible to realize the almost unlimited offensive powers of a modern aeroplane if it were given means of projecting its bombs, which would be in reality projectiles of unusually high explosive properties, in any direction from the horizontal to the vertical, with any initial velocity of from 1,200 to 1,500 feet per second.

The invention of the non-recoil gun at once solved the problem, for enough is known from the guns already built and in service, to design and install guns of from 6-inch to 8-inch caliber that will be within the weight limitations of the recently constructed aeroplanes. Such planes are known to have an effective weight carrying capacity of about one and a half tons exclusive of fuel and pilots. This is well in excess of the weight necessary for the latest design of 6-inch non-recoil gun with a liberal

supply of ammunition. This gun will give a hundred pound projectile a muzzle velocity of 1,200 feet per second.

Equipped with this gun the aeroplane will indeed become a more powerful instrument of warfare than the dreadnought of to-day.

Much will depend, of course, upon the degree of accuracy of fire attainable from an aeroplane. The conditions under which such guns are used are so different from those pertaining to land and naval guns that the ordinary formulae pertaining to trajectories do not apply directly. But without going into mathematical investigation, a little consideration of the conditions will at once show some of the great advantages ballistically to be obtained when firing from high altitudes. Guns fired from the surface of the earth can obtain comparatively long ranges only by being fired at a high angle of elevation, so that the projectile at approximately the middle point of its flight, attains a considerable altitude. The aeroplane gun on the other hand starts its projectile from a comparatively great altitude, and as a consequence has a corresponding greater range, or an equal range, with a much lower initial velocity. Not only is there an advantage in the form of long range hitting, due to the high altitude, but there is also a concurrent advantage due to the action of gravity. There is a great amount of potential energy stored in a projectile when fired from an altitude of several thousand feet and this energy is utilized to a certain extent in overcoming the resistance of the atmosphere.

Another great advantage to be enjoyed by aeroplane guns when compared to land or naval guns is the unrestricted view which can be obtained from above. In land battles, where artillery participates, there is frequently interference due to timber, hills, buildings, etc., which seriously hampers operations. A battery of aero guns would never be restricted due to these causes.

To obtain accuracy of fire from land guns it is necessary to know accurately the range, to be able to see, to measure or estimate the point at which the projectile strikes. This will be comparatively easy for the aeroplane. Indeed, when it is remembered that in the present war abroad practically all the spotting for artillery fire is done by aeroplanes, and the corrections signaled to the guns in the rear, it will be at once seen what advantages would be obtained in the matter of rapidity and accuracy of fire if the aeroplane carried its own guns. There will be of course certain elements such as height and speed that will tend to produce errors of shooting, but it is correspondingly believed that the accuracy of observation possible should in a large measure compensate for these and it is entirely possible that as accurate shooting can be done from the air as from a gun aboard a ship or on land.

The field of operations for such aeroplane guns will be very extensive. They can be used with equally good effect against troops in the field, fortified camps or cities, ammunition depots and factories and all places of military importance that are beyond the range of the land batteries. Their extreme mobility and large radius of action will enable them to travel far into the enemy's country and bombard with telling effect the most important of that country's defenses. Against battleships and warships in general they will be able to compete on more than equal terms. The great disparity in size of the targets will more than compensate for the inaccuracy of fire of the aeroplane gun due to the unstable gun platform and the high speed at which it is traveling. Its projectiles will have sufficient weight and velocity to penetrate the most heavily armored decks of the largest battleships, and, exploding in the interior of the ships, will almost certainly result in destruction. In addition this novel weapon will offer a means of attack against submarines. This type of vessel is entirely immune from ordinary gun fire, and no satisfactory method of defense against its attacks has been developed in the present war. While, as is well known, an observer at or near the surface of the water cannot detect the presence of a submarine, it is also true that it becomes visible when the observer is at a considerable height above the surface of the sea and nearly vertically over the vessel. During an attack a submarine will ordinarily run at such a depth as to be immune even from vertical fire, but at intervals, in order to correct its course, the boat must come sufficiently near the surface to take observations through her periscopes. While making such observations the hull of the boat will be only from 13 feet to 15 feet below the surface of the water while the top of the conning tower will be only from six to nine feet. Under such conditions the boat will offer a fair target to an armed aeroplane provided the latter can maneuver itself into a position nearly vertical over the boat, and even a 3-inch non-recoil gun would be of sufficient power to traverse the intervening water and penetrate the deck of the submarine.

Non-recoil guns of large size may also be mounted upon dirigibles, armored motor cars or upon small boats, giving such craft greatly increased offensive powers without increasing the size or impairing their mobility in any way.

A Novel Steam Superheater

By Frank C. Perkins

THE accompanying illustration shows a most interesting form of steel superheater designed for attachment to some classes of water-tube boilers. This superheater was constructed for a 300 horse-power boiler of 150 pounds water pressure and 150 deg. Fahr. of superheat. It is a fact that has been established beyond doubt that "mineral oils do not undergo chemical change under a temperature of 700 deg. Fahr.," and that "cast iron increases in tensile strength up to a temperature of 800 deg. Fahr."

It is held that there is no reason why the temperature to which steam is superheated for driving any type of prime mover should be restricted to less than 700 deg. Fahr. It is claimed that it is the combined "flash" and "wire-drawing" method of superheating on which superheaters of the Schmidt, Heine, Stirling and Foster types are dependent, which *brings about chemical change* of steel during the process of superheating, and results in difficulty in maintaining efficient lubrication of engines to which steam so superheated is applied for driving, and not the temperature to which the steam is superheated. The chemical change undergone by steam superheated by these types of superheaters results in the production of a volatile and combustible gas, as one can easily prove by means of a simple experiment.

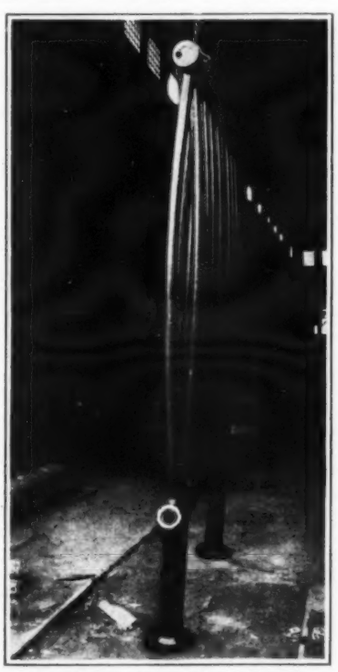
It is only necessary to attach a quick opening valve not less than two inches in diameter to the outlet header of any of the superheaters mentioned, then open the valve (to the atmosphere) and close it as quickly as possible, allowing just a puff of steam to come in contact with a lighted torch (say piece of waste tied on to an iron rod) and a sharp report or explosion will take place when the puff of superheated, but chemically changed, steam comes in contact with the live flame of the torch.

It is maintained that if one tries this experiment with ordinary saturated steam, or with steam superheated to any temperature by a superheater of the type illustrated in the photograph, the only result will be that the steam will extinguish the flame of the torch with which it comes in contact. When cast iron fittings are distorted by superheated steam, such distortion is caused by the chemical change undergone by the steam, and not by the temperature to which the steam is superheated, as such fittings should increase in tensile strength and therefore be safer to use at high temperatures than at the temperature of saturated steam at any pressure.

It is stated that some of these superheaters recently put in commission at a large power plant in this country are delivering steam superheated to 750 deg. Fahr. (372 deg. Fahr. of superheat) to the high-pressure cylinders of the 6,000 horse-power Hooven-Owens Rentschler gas-steam engines, using the same quality cylinder lubricants as formerly used with saturated steam, the lubrication with high temperature steam being more efficient than when saturated steam was used.

Fabric Break and Clutch Linings Successful*

THE extent to which fabric has replaced all other substances as a friction material for brake and clutch linings is hardly realized even by engineers. Mr. J. Oswald, of Glasgow, in a paper read before the Association of Mining Electrical Engineers, dated the use of cotton for this purpose back to twenty years ago, when cotton brake blocks were first tried on horse trams and were found to have points of very great superiority over wood, especially in their efficiency when heated by friction.



A superheater for water-tube boilers

Since that time great improvements have been made in the manufacture of friction fabrics. The bonding cement has been rendered more heat proof, and a process has been developed by which the burning point of the fabric itself is raised 75 per cent.

Fabric lining is of two principal materials—cotton and asbestos. According to Mr. Oswald the cotton fabric has the highest coefficient of friction—0.5 to 0.7—and is capable of absorbing much greater work in foot-pounds per square inch at a given pressure than asbestos material. The coefficient of friction rises with increased temperature and is practically unaffected by oil and water. In actual test results obtained by the National Physical Laboratory on cotton material the work absorbed in foot-pounds per square inch per minute was 72,000 dry and 70,000 when lubricated, the pressure being 39 pounds dry and 160 pounds lubricated.

The choice between cotton and asbestos is determined in part by the amount of heat that is likely to be generated. The heat limit with cotton is 400° F., and in all cases where this heat limit is likely to be exceeded it is advisable to adopt asbestos material. The coefficient of friction of this material is 0.3, and it is remarkable that it practically remains constant under varying conditions. Its value lies in its great heat-resisting qualities, which recommend its use on exceptionally heavy and prolonged braking or similar duties. On account of its nature asbestos material is usually reinforced with brass wire, which makes it more expensive than cotton.

Failures with fabric linings are not unknown, but the majority of them Mr. Oswald ascribes to preventable causes: (*a*) To the use of wrong material; (*b*) to failing to keep the fabric face clear of the opposing face when the brakes are out of action; (*c*) failing to insure that the fabric is kept well home when applied, or, in other words, "followed up"; (*d*) incorrect fixing of linings to the engaging media; and (*e*) expecting too much from brakes which have been under-dimensioned by the makers for the duties they have to perform.

Collieries, it appears, are now taking up fabric linings extensively for brakes on main winding engines and haulage gears. Their use saves the rope considerably on account of the smoother action, the upkeep cost is even less than with wood, and there are further advantages in the shape of improved control and speedier working.

The immediate reason for introducing fabric linings for the brakes of the underground railways is interesting. Iron brake blocks give off an amount of iron dust which in the aggregate reaches surprising figures. Three-quarters of a ton of brake dust per mile has been proved to be produced every month in the New York subway. This not only short-circuits the electric signalling apparatus and causes stoppage of trains daily, but as the dust settles on the track the oil from the motors becomes mixed with it and forms a highly inflammable mixture.

An accumulation of the sort mentioned, combined with red-hot sparks from the metal blocks, caused the Paris fire a few years ago, in which 480 persons lost their lives. Fires in London underground railways have also been attributed to this cause. The rapid running of the trains throws off oil from the motors under the coaches, and as the atmosphere is charged with metal dust a very inflammable mixture is scattered all over the train. Partly to prevent these troubles cast-iron blocks were abandoned in favor of cotton linings. Since their introduction not a fire has been reported on any of these railways. Continued use led to the discovery that there was no appreciable wear on the tires, both tires and rails being highly burnished. A further very important result is that since fabric linings have been used rail corrugation and flats on wheels, which commonly existed with the use of metal brake blocks, have disappeared.

*Extract from *Yorkshire Post*, of Leeds, forwarded by Consul Augustus E. Ingram, Bradford, England. U. S. Commerce Reports.

The Healing Art—II*

Legends and Lore of Its Genesis

By Raymond Crawford, M.A., M.D., Oxon. Physician to Kings College Hospital, and King George Military Hospital, London; Fellow of Kings College, London

ANIMAL TRANSFORMATION—FOREKNOWLEDGE OF WEATHER

Melampus is said to have learnt the purgative action of hellebore from observing its action on goats. He used the drug with success in the cure of the daughters of Prœtus, King of Argos, who fancied themselves metamorphosed into cows, to gratify the anger of Hera. Accounts differ as to whether Melampus sent them the milk of goats that had eaten hellebore, as nowadays one might send rodagen, or gave hellebore itself, joined with certain superstitious remedies. Having regard to the action of the drug, the wonder is that the ladies were not still further confirmed in their hallucination. In this fabulous setting we catch a glimpse of the old-time belief in animal transformation, which found its most extravagant expression in the state of lycanthropy. Ovid[20] describes the transformation of Lycaon into a wolf. Aetius, Avicenna, Oribasius, and others speak of it as frequent. Burton[21] descants on the wide prevalence of this mental disorder in olden times. The idea of the were-animal struck its deepest roots in Scandinavian and North-German soil; men fancied that by donning the skin of a wolf they could becomes wolves at pleasure. It is less common in Greek and Latin folk-story, but a familiar example is to be found in the eighth Eclogue, where the lover, by using Pontic herbs, is enabled to see Moeris transformed into a wolf. Lycanthropes, like wolves, often lay hid during the day and at night wandered abroad, haunting the graveyards and barking and howling.

Knowledge of the action of hellebore was not the only gift bestowed on Melampus by animals. His gift of divination he owed to some serpents that he rescued from death and reared; they in return cleansed his ears while he slept, with their tongues, so that when he awoke he understood the language of birds, and so learnt the mysteries of the future that it is their privilege to foreknow. In ancient medicine prognosis was esteemed as highly as healing, and man desired to share with animals, and especially with birds, their faculty of foreknowledge. Nature seemed to have endowed them with power to presage the weather by observing the skies—a gift of first importance to a primitive agricultural community. Vergil[22] mentions, as foretelling the coming of rain, the flight of cranes and swallows, the heifer scanning the face of the heavens, the clamor of rooks and of ravens, and the plaintive chatter of frogs in the fens. In Germany even now green-frogs in tall glass bottles are used as barometers; in fine weather they ascend, in wet weather they descend little wooden ladders, each step of which marks a degree. Buckland succeeded in using leeches similarly for the same purpose. Many an old maid to-day in London will tell you that her cat keeps close curled up before the fire when snow is coming.

OTHER EXAMPLES OF BELIEF OF KNOWLEDGE GAINED FROM ANIMALS

Besides foreknowledge of the weather, man was believed to have acquired much other useful knowledge directly from animals. The ancient Egyptians believed that the art of writing had been learnt from the sacred baboons that were kept in their temples; when a fresh baboon was admitted, its fitness was tested by the priest putting writing materials into its hand and calling upon it to write. These sacred baboons were held to have originated the division of day and of night into twelve equal parts, so to afford a model for construction of the water-clock.

There was a widespread tradition that music had been learnt from birds, and chief among them the nightingale; in Hindoo poetry it is the kokilas, the Indian cuckoo, that teaches melody. Birds are often credited with bringing down fire from heaven; in Polynesia it was a red pigeon, in French folk-lore the wren. The tale runs[23] that all the other birds, except the owl, contributed a single feather apiece to replace the scorched plumage of the wren, so as to keep it warm in the coming winter. For its ill-nature the owl was condemned to eternal seclusion during the warm day, and to perpetual suffering from cold during the night, and the other birds maintain the punishment by pestering it if it appears in sunshine. Every nation has its Prometheus; in Greek legend it was a man, among the North American Indians a stag; but the myth never tells how the fire was produced, in conformity with the circumstance that the maintenance of fire accidentally produced seems always to have antedated the discovery of how to produce it.

It would be interesting to hear the chatter of the native East African over the domestic meal after watching an aeroplane soaring in the sky; he would probably recognize in its movements, its outline, and its mode of propulsion another gift of knowledge from birds to man, confusing what is in part due to imitation with what appears to be due to instruction. Ælian[24] asserts that birds know all the remedies that man employs; he cites the application of marjoram to their wounds by partridges, storks, and pigeons. Pliny,[25] too, gives a list of purgative herbs used by birds, but, if we can be sure of their identity, few, if any, possess the properties claimed for them.

The sedative properties of lactucarium, or lettuce, were widely accepted; Aristotle and Ælian[26] state that it is used by the dragon to relieve a distended stomach. Venus was said to have lulled her grief at the death of Adonis and repressed her desires by throwing herself on a bed of lettuces. Experiment has failed to show any sedative action in the juice of lactuca, and belief in its hypnotic properties is probably due to the similarity in appearance and smell to the juice of the poppy.

Fallopius[27] asserts that the ape taught man the laxative properties of cassia, and in view of the fondness of monkeys for fruit it is not impossible that man may have observed its laxative effect.

Dogs were said to have taught man the use of pellitory for expelling calculi; one wonders whether the belief may have arisen in an attempt to explain the name.

ANIMALS AND KNOWLEDGE OF NATURE OF FOOD

If man learnt the use of drugs from animals, he must have paid a price in some cases for his knowledge. Thus horses eat aconite with impunity; birds, rabbits, and many herbivora belladonna, and its effect on horses and donkeys is but slight. Goats, sheep, and horses eat hemlock without ill effect, yet it poisoned Socrates. Henbane has little effect on sheep, cows, pigs, and pigeons, and ipecacuanha does not excite vomiting in rabbits.

Animals seem to acquire their knowledge of poisonous plants from experience, and not by any innate instinct; our domestic animals, when transported to other countries, at first eat poisonous plants, which they learn afterwards to avoid. Snell observed that strange sheep frequently fell victims to the poisonous hellebore that grows abundantly in the valley of the Ahn, but that it is carefully avoided by the sheep of the neighborhood. Pliny[28] was evidently aware that cattle did avoid certain poisonous plants, and he instances the anagallis as one; but he goes further and asserts that if they eat it by mistake they have a remedy at hand in a plant that is an antidote. Lambs and calves, grazing in the same field as their mothers, are far more prone than they to eat poisonous plants. Morgan[29] concluded from observations of feeding young birds with various caterpillars, beetles, and worms, that, in the absence of parental guidance, young birds have to learn by experience what is good to eat and what is not, and that they have no instinctive aversions. At first they peck at everything, but once they have found that a particular thing is distasteful or harmful, in future they entirely avoid it. Tegetmeier found that pigeons reared exclusively on wheat or barley would starve before eating beans; but if a bean-eating pigeon were introduced among them they would soon imitate and adopt the habit, instinct yielding to experience; in the same way fowls sometimes refuse maize, until they are placed with maize-eaters, when they not only eat it, but become exceedingly fond of it. Newly caught birds are apt to starve unless the cage-food is mixed with food to which they are accustomed. Each bird seems to make its own observations, its own experiments, and its own discoveries in the matter of food, and the rapidity with which knowledge acquired may be propagated is shown by the readiness with which the habits of other members of the species are imitated.

The taste for meat is not infrequently acquired by herbivorous animals, and once acquired may amount to a veritable passion. Parrots[30] that have lived on insects and berries have been known to acquire such a liking for meat that they have actually pecked to death animals as large as sheep and porpoises, so as to eat their flesh in place of their habitual food. Horses will take to flesh-eating, and have been known to snap up young pigeons and chickens; meat diet is said to render them savage. Reclam[31] saw squirrels and rabbits gnaw greedily bones thrown to them, though they had abundance of vegetable food; both Darwin and Brehm record instances of cattle taking to a diet of fish on certain islands when pasture failed them.

FOODSTUFFS IN PRIMITIVE PHARMACY

Man, doubtless, will have acquired much of his knowledge of the nutritive and medicinal value of plants by the same method as the lower animals, by experience. Like them, too, he will have profited by imitation, and imitation embracing his observation of the habits of the lower animals. It must have been of immense importance to man, when he depended largely for food on wild animals captured in the chase, to watch them closely so as to know their habits. Baited trapholes, being one of the chief modes of capturing game, a knowledge of the favorite foods of animals must have been a first condition of success. This, together with his passion for their domestication, to be at once his companions and his servants, must have given him an intimate knowledge of their foods and their effects. Further, there is not wanting evidence that he did use animals and even his fellow[32] men as subjects of research in this field, for the Philippine pygmies, if they fancied a fruit were poisonous, would soak it for two or three days, and then give it to one of their dogs; if he seemed none the worse, they would eat it themselves. The American Indians first tested arrow poisons on the old women of the tribe.

That a good deal of man's medicinal knowledge arose accidentally in his efforts to extend the range of his food-supply is suggested by the prominent place occupied by food-stuffs in primitive pharmacy. Honey, milk, butter, and cheese appear and reappear in every conceivable combination. We shall be less likely to underrate the importance of honey in the dietary of primitive man if we bear in mind that it was his only readily available supply of sugar. Honey and the honey-bee were surrounded with a sacred halo of mystery in the mind of the primitive zoologist. He believed the bees to be generated from putrid flesh, just as fish and frogs seemed to be generated from the mud, when the rain filled the pools with water. This was not an unnatural belief, for he saw the maggot-like Larvæ in the honey-comb, and they seemed to him for all the world the same as the maggots engendered in fly-blown putrid meat. Pure honey, engendered in the air, might be found in its elemental purity at dawn deposited on the leaves of trees and elsewhere; how else can we account for the deposit on the leaves of the lime? Pliny[33] speculates as to whether this liquid is the sweat of the heavens, or saliva emanating from the stars, or an exudation from the air, purified in the process of distillation. Ah! if only it came to us limpid and untainted, as when it set forth on its downward path, before it is corrupted by exhalations from the earth or by the admixture of the juices of flowers and by elaboration in the stomach of the bee! Pliny[34] describes various kinds of honey with the gusto of an up-to-date apiarist, but he awards the palm to summer honey, for "Nature has revealed in this substance properties most valuable to mortals . . . for, after the rising of each constellation, and more particularly those of the highest rank, or after the appearance of a rainbow, if a shower does not ensue, so that the honey-dew becomes warmed by the rays of the sun, there is produced a medicament, and not real honey, a gift sent from heaven for the cure of diseases of the eye, ulcers, and maladies of the internal organs. If this be taken at the rising of Sirius, and this should happen to fall on the same day as the rising of Venus, Jupiter, or Mercury, as is often the case, the sweetness of this substance and the power it possesses of restoring men to life are not inferior to those attributed to the nectar of the gods." Long before the time of

*A presidential address delivered before the Section of the History of Medicine of the Royal Society of Medicine, reported in *The Lancet*.

[20]Metamorph., I., 7.
[21]Anatomy of Melancholy, ed. 1804, vol. i., p. 13.
[22]Georg. I., 378 seq.
[23]Watkins: Gleanings from the Natural History of the Ancients.
[24]Nat. Anim., V., 46.
[25]N. H., VIII., 41.
[26]H. A., IX., 6 and Nat. An., VI., 4.
[27]Purg. Simpl., 35.
[28]N. H., XXV., 92.
[29]Habit and Instinct.
[30]Buchner: Mind in Animals.
[31]Mind and Body, 1859, p. 300.
[32]Zuniga: Franciscan Chronicle, 1738; and Scott-Elliot: Prehistoric Man and his Story.
[33]N. H., XI., 12.
[34]Ib., XI., 14.

Pliny men were aware of the occasional poisonous properties of honey, and rightly attributed them to the flowers from which the honey was gathered. Xenophon records the toxic effects of the honey at Trebizond on some of the Ten Thousand, which has usually been referred to the Azalea Pontica and Rhododendron Ponticum, which abound in that neighborhood; poisonous honey is met also in Pennsylvania, gathered from Kalmia latifolia. All the stories of Mithridates having been the discoverer of antidotes seem to be referable to the knowledge that many poisonous plants grew in his kingdom on the shores of the Euxine; as ducks were seen to feed on the herbage with impunity, it was not unnatural that their blood should be regarded as an antidote to poisons.

Mixtures of honey with milk or butter are favorite dishes of the Arabs and Hindoos, and recall the Biblical injunction, "Butter and honey shall he eat." Honey is much used in India in ointments in place of animal fats, which putrefy readily in hot climates. In this country it has been used as a vehicle for drugs, as in mel boracis, or as a palatable addition with mildly laxative effect in confectio piperis. For centuries it has been used as a local application to the aphthæ of children, and Soranus attributes this not to its inherent medicinal qualities, but to the fact that it was taken from hives near the tomb of Hippocrates.

Milk was much used as a vehicle for drugs and butter as an ointment or the base of an ointment, while Zoroaster seems to have anticipated Metchnikoff by living 30 years in the wilderness upon cheese prepared in such a way as to render him insensible to the advances of old age.

Some substances probably found their way into medicine for no better reason than that they were generally ready to hand. Anyone who has lived among the sons of the soil or among fishermen on remote coasts must be familiar with the tendency to use both internally and externally whatever is first to hand. I have seen a farmer pick up a handful of dust and mix it with dung from the hen-roost and then apply the mixture to a sore on a sheep's back; cobwebs are used to staunch the bleeding of a cut, and so is tobacco; leaves are used in the West Indies as plasters and as dressings; and I am not at all sure that dung pharmacy, for all its later elaboration, may not owe its origin in part to this tendency.

Magic was another prolific parent of medicinal remedies; the Echeneis is a good illustration of one introduced in obedience to the dictates of sympathetic magic. This genus of sucking fishes has on its head an adhesive disca by which it attaches itself to sharks, turtles, and other marine animals, and in default of these to ships. Its object seems to be to ensure an ample supply of food by increasing its range of locomotion. Its retarding effect on the bodies to which it attaches itself seemed to suggest the desirability of its use for the same purpose in medicine. We learn from Pliny[35] that it was used in love philtres, apparently to prevent the affections from wandering, and in obstetric medicine to check bleeding from the womb, to prevent procidentia uteri, and to delay premature birth.

POISONS AND THEIR ANTIDOTES

In the matter of poisons and their antidotes, it was believed that man had learnt many valuable lessons from animals. The poisonous bite of the serpent and the source of its poison were bound to excite speculation. Ælian[36] lays it down that animals acquire poison by feeding on poisonous things; thus the sting of wasp, he says, is far more dangerous if it has tasted a viper, and a fly, if it has touched anything of the kind, has a more harmful bite and causes greater pain. Homer[37] depicts the dragon lying before its lair eating baleful herbs, and Vergil[38] paints the same picture of the snake. Numerous antidotes to the snake's poison were in use. Pliny[39] says that the plant chondrion, the identity of which is obscure, was employed with good effect, as field-mice were known to eat the plant when bitten by snakes. The same writer[40] asserts that the tortoise eats the plant known as cunile bubula so as to recruit its powers of effectually resisting serpents, and he recommends the juice of the plant in wine to be taken internally, and the bruised leaves to be applied locally for their bite. Aristotle[41] says that the tortoise, when it has eaten a snake, feeds on marjoram, and he declares that one was seen to do so repeatedly during its repast; seeing this the observer rooted up the marjoram with fatal results to the tortoise. Some of the larger tortoises and turtles do prey on small reptiles, and this must have seemed to call for explanation to those who were familiar for the most part with the herbivorous diet of the smaller land species. The tales of the weasel and the ichneumon in this connection seem to be all referable to the mongoose. Lyddeker identifies the ichneumon with the Egyptian mongoose, and the similar appearance of the weasel not unnaturally led to confusion. Both Pliny and Ælian[42] say that the weasel protects itself against the serpent by eating rue, but recent experiments tend to show that the weasel will not attack serpents. Wilkinson, in his "Ancient Egyptians," says that an Arab assured him that the ichneumon is very dexterous in killing serpents, and that, whenever bitten, it has recourse to a plant, of which it eats part and applies part to its wound, and then returns revived to the encounter. According to Lindsay,[43] the Indian mongoose, when poisoned by a snake-bite, uses Mimosa octandra as an antidote; the mongoose plant, Ophiorhiza mungos, is used for the same purpose in India. Most countries have their particular antidotal snake-root; in North America and Canada the roots of Liatris spicata, Eryngium anquaticum, Eupatorium altissimum, and Asarum Canadense are all in favor; and elsewhere Aristolochia serpentaria, Polygala Senega, and Cimicifuga racemosa have all been used for the same purpose. Most of these contain active principles, which in warm decoctions induce diaphoresis or diuresis, the idea being that the poison will be eliminated by the skin or kidneys.

Spider's venom was regarded with only less fear than that of the serpent. The tale was told that the toad, when bitten by a spider, ate the leaves of the greater plantain, and succumbed to the bite when these were not available. Deer were said to protect themselves from the poison by eating crabs.[44] The victims of that epidemic form of convulsive hysteria known as tarantism, which flourished over wide areas more particularly in Italy, believed themselves to have been bitten by the tarantula spider. So ingrained was this belief that Constantine the African, the most learned physician of Salerno, stated that those who were bitten were liable to eject from their stomach and bowels substances resembling a spider's web. It was nevertheless not an animal venom, but a mental poison that was propagated from person to person in a human soil sensitized by long years of pestilence and warfare. The efforts of the victims to cure themselves by wild dancing, excited and maintained by the music of the flute, may be regarded as rational therapeutics according to the notion of the day, for clearly the chemical poison should find an exit in the sweating provoked by the violent exertion of the dance. Just so, when disease is conceived as due to a demoniac mannikin within the sufferer, savages resort to violent bodily movements to effect its expulsion.

These various legends of the effect of spider's venom on animals and man rest on the most slender basis of fact. It is true that all spiders have poison-glands which communicate with fangs in the mandibles, but the smaller species are quite harmless to man and the larger animals, and it is open to question whether their poison plays an important part in the killing of insects. With regard to the tarantula there is little evidence to show that its bite can cause more than local irritation in man and other large animals; this, of course, in rare and unfavorable circumstances, may be the starting point of a secondary generalised poisoning. Some of the larger spiders can undoubtedly kill small birds and animals, but Warburton[45] holds that this is due to the unerring accuracy with which they drive their jaws into the vital nervous parts of their victims. Fabre, on the contrary, insists that death does not depend on the bite involving a vital part. There were some apparently, even in the seventeenth century, who did not believe in the poisonous effect of the tarantula's bite, for Ferdinando, a physician of Messapia, considered the symptoms to be those of a melancholy dependent on the imagination.

EVIDENCE OF HEALING PRACTICES AMONG ANIMALS

We may now pass from the domain of legend to the more prosaic consideration of such substantial evidence as there is of the existence of healing practices among animals, and we shall find it disappointingly slight.

Livingstone left it on record that some of the anthropoid apes staunch bleeding by pressure with their hand on the wound or by stuffing it with leaves, turf, or grass. Dr. Thomas Savage has recorded the same practice of the chimpanzee. Moore[46] extends the range of action to the young in the case of a female monkey which tore leaves from the trees as it fled with its wounded baby in its arms and stuffed them into the bullet wound to staunch the bleeding. Darwin[47] notes that the long-armed apes sometimes use their arms as crutches, swinging their bodies forward between them. The smaller monkeys exhibit considerable skill in the extraction of thorns. They search themselves for parasites and assist their comrades by searching the head and such other parts as each is unable to reach for itself. When a flea is caught they examine it critically and then swallow it. Moore tells of an orang-outang that was once bled for some illness which, whenever afterwards it was ill, would point to the vein in its arm, as though he wished the operation to be repeated. These records serve at least to show how readily monkeys learn to appreciate a remedy by which they have benefited. As we descend in the scale of creation, we cease to find any sure indications of the existence of a therapeutic sense; it is more than doubtful if we can refer the licking of wounds or the eating of grass by dogs to this category.

Cats exhibit a keen sense of maternity, and a mother-cat will sometimes attend fondly on its daughter during the birth of its kittens. Cabanés says that they have been known to bite the cord and carry off the kittens to their own nest and there lick them clean. I myself can testify to what appeared to be an exhibition of the keenest sympathy of one female cat to another in these circumstances, anxiously brooding over and licking the expectant mother; but it may well be that this was no more than the prompting of a confused maternal instinct.

Cabanés[48] has some wonderful tales of avian surgery, so wonderful that, for all his sincerity, they would seem to call for further investigation before acceptance. He cites M. Fatio as authority for the statement that woodcock, corn-crakes, and snipe have been known to pluck their feathers and make most elaborate dressings for wounds and for fractured legs. In another instance he alleges that a black-bird with a broken leg, failing in its own efforts to dress the fracture, summoned its companions with a cry and then ligatured it admirably. It is not difficult to see how a wounded and bleeding leg may acquire an adhesive dressing of feathers without postulating the purposive use of the bird's beak in providing it, and still less a summons to other birds to assist at the operation. Anyone familiar with wounded game knows how frequently a matted tangle of blood and feathers is found adhering to a wound. In another case Cabanés mentions a quail found in Savoy with its left leg broken above the ankle. It was wearing a dressing composed of blades of grass rolled circularly round the site of fracture and bound to one another; the whole formed a lump the size of a hazel-nut, and in spite of the riding of the ends of the bones good union had been obtained. Here, again, it seems easier to imagine an accidental winding of grass-blades round the broken ankle in the bird's frantic efforts to liberate the hanging foot caught in the grass.

That auscultatory percussion is practised by birds and other animals is beyond question, yet it can hardly be argued that man adopted the practice from them. Woodpeckers, nuthatches, and tree-creepers tap the bark of the trees to see if it emits a hollow sound; if hollow, they continue to tap till any insects emerge; in the same way the aye-aye lemur taps the bark in search of caterpillars, and employs its finger as a probe to search for them.

From all this there seems to emerge a strong presumption that below the level of the monkey tribe a healing sense is not existent, and only among the anthropoids is there unmistakable evidence of even a lowly stage of its development. In what I have said I have intentionally limited my remarks to curative medicine, but there remains a further fascinating chapter of animal anticipations of sanitary science, with which we will deal on a future occasion.

[35] N. H., IX., 41.
[36] Nat. Anim., IX.
[37] Iliad, XXII., 93.
[38] Æneid, II., 471.
[39] N. H., XXII., 45.
[40] Ib., VIII., 41, and XX., 61.
[41] H. A., IX., 6.
[42] N. H., VIII., 41, and Nat. Anim., IV., 4.
[43] W. Lauder Lindsay: Mind in the Lower Animals, ii, 384
[44] Aristotle: H. A., IX, 5; and Pliny: N. H., VIII., 41.
[45] Cambridge Manuals, "Spiders."
[46] Universal Kinship.
[47] Descent of Man. Pt. I., ch. ii.

Production of Blue, Green, Black, and Gold Colors on Glass

THE author concludes that so far as present knowledge goes, satisfactory colors can be burnt on to glass only by the use of compounds of copper and silver, and possibly gold and platinum. A black is produced by burning on copper compounds in the ordinary way with a subsequent burning under reducing conditions. A third burning under ordinary conditions gives a red color. The first burn with copper compounds gives a green. A yellow, burnt on in the usual way, is converted into a bright golden color by a second burn under reducing conditions. Blues cannot be produced by burning cobalt compounds on to glass. Compounds of other elements also gave negative results.—Note in *Jour. Soc. Chem. Ind.*, on an article by L. SPRINGER in *Keram. Runds.*

Granules in Photographic Plates.—An Investigation of the condition of silver bromide granules in dry plates indicates there is a change of form on development. Some developers make fine grained negatives; they develop only a part of the AgBr granule. There is no general law that the coarsest grained emulsions are most sensitive to light.—*Phys. Zeits.* Nov. 1, 1916.

[48] Bulletin Général de Thérapeutique, 1912.

Welding in Gas Main Construction

F. L. Hadley

THE subject which is treated in this paper is one which has become of great interest to all gas men and especially so to those interested in the construction and maintenance of lines and the transportation of natural gas from the field to the different markets.

From what we now know of the oxy-acetylene method of welding pipes together it appears as if the ideal method of constructing natural gas mains has been discovered and that it will mean as great a boon to the natural gas industry of the future as the discovery of the coupling was to the past, and while it is true that this method may not lead to the building of as many long lines to reach distant markets as did the development of couplings used in connection with plain end pipe, yet it will mean that the leakage as being one of the principal factors in the transportation of gas will be practically eliminated, effecting a saving of many thousand dollars annually to all of the large gas companies, besides giving us cheaper lines to build and operate.

This method of laying lines has been tried out very extensively by artificial gas companies during the past few years and in all cases of which we have knowledge it has been found to be very successful both in economy and in securing good tight lines. Some of the eastern companies are now welding all their extensions including the mains and service lines down to ¾-inch pipe. At the time when this paper is written the writer is engaged in installing such a plant which will consist of 14 miles of 8-inch, 9 miles of 6-inch and approximately 10 miles of smaller pipe together with several hundred service lines of ¾-inch pipe all of which is to be welded, it being our intention to complete the entire plant without the use of a single fitting of any kind, with the exception of valves and stop cocks.

The writer desires to give his experiences in building approximately seven and one-half miles of 10-inch line during last fall on which this method of joining the pipe was used in place of couplings or collars. This line was laid through rolling country with the highest hills of probably 300 feet being in some sections somewhat rough with a number of small ravines. The pipe used was standard 10-inch I. D. line pipe furnished in long lengths which averaged about 35 feet to the joint. In order to facilitate the welding we had the ends of the joints chamfered or beveled at an angle of 60 degrees which was done in the pipe mills without extra charge. By having the pipe thus chamfered the welder was able to start welding at once after the joints were lined up, otherwise it would be necessary that he melt down the edges of the pipe with the flame to secure a foundation before he would be able to start welding.

Heretofore in laying welded pipe we found that it was customary to lay the pipe in sections along the ditch and by turning the joints by means of tongs to allow the welding to be done on top of the pipe. We decided to make a little departure from this method and wherever the ground was suitable we laid the pipe joint by joint directly over the trench and did the welding without turning the pipe. While the welding was somewhat slower by reason of it being necessary to weld underneath the pipe, we found that we gained time in the end as we were able to slack the pipe directly into the ditch after the welds were made and to make the bends the same as if we were laying screw pipe; that is by building fires and heating the pipe wherever it was found necessary to place a bend.

Owing to the rough character of the ground we were obliged to make a great number of these bends, but in nearly all cases they were made as the welding progressed. In a few places we had men go ahead and make bends which were placed in the line when the welder came up but as a rule this was only to gain time in some certain rough section of ground.

In testing out this line we used 100 pounds of gas pressure from one of our compressor stations and when completed was found tight with the exception of five leaks which were very small being nothing more than little pin holes in the welds. These leaks can be easily repaired by placing additional metal upon the weld after the pressure has been taken off the line.

During the laying of the line we subjected it to many severe tests in order to find out the strength of the welds and in only one case were we able to break them. For instance we would hold the pipe up to the top of the trench with one of the wooden horses and lower it into the ditch on both sides of the horse, then we would suddenly let go of the pipe and allow it to fall without any support to the bottom of the trench, then at other times we would leave 5 or 6 joints swinging in order to test the strength of the weld. We would make the bends in some cases nearly at the weld but at no time did we have any trouble with them not holding although the strain was very great where the bends were made without the line being blocked or braced. In fact we tried out the strength of the welds in every possible way in order to find out if there were any weak points in the construction of a welded line. In other words we did not want to give up the idea of welding our lines in the future unless it was proven to us that it was not practicable.

This one break which we had during the building of the line was caused by a poor weld, the pipe not being perfectly joined together, although at a casual glance it had the appearance of being as strong as any of the other welds; yet upon a more careful examination we found that the two pipes had been simply tacked together with metal and the iron melted in between them without being united and making a continuous pipe. Fortunately for us the welder who made this weld was discovered in time otherwise we might have had more trouble with defective welds.

Before and during the building of this line there was considerable discussion as to the contraction and expansion on a welded line of this length, many holding that the line would pull apart at the welds owing to the contraction and expansion that they expected we would find on a line such as we were laying with only 20 inches of covering, that being the depth which we were having it buried. However, we did nothing to take care of this as we took it for granted that the pipe itself would take care of any contraction or expansion that there might be. In other words, we figured that when the line was finished we would have one continuous joint of pipe the same as if we secured a seven-mile length from the mill and if it had been possible to secure such a joint of pipe nobody would have thought it necessary to have it cut and expansion joints or sleeves put in. In this connection I can advise you that we have not had the slightest trouble with the line pulling apart, although there has been some severe cold weather since the line was put in commission. There have been two breaks, the first one shortly after the gas was turned into the line, which upon examination showed plainly that it came from a defective weld in which the pipe had the appearance of being burnt. The other break was caused by a sink in the surface of the ground at a coal mine and was a break which would have occurred on any line under like circumstances. Neither of these breaks showed any signs of there being contraction of the pipe although the break at the mine took place during very cold weather. To secure welders we were obliged to pay a rate somewhat higher than the regular rate yet with this high cost of labor the cost of the welds came slightly under the price of standard couplings such as is generally used on like lines, but this being our first experience in this kind of main line construction our costs were likely greater than they would have been had our experience been more extensive. I believe that a welded line can be laid with such economy that the cost of the joints will not be over two-thirds of what it would be if couplings were used.—*Gas Industry.*

Torsion and Bending Tests

THE main feature of a number of experiments described by Dr. William Mason before the Institution of Mechanical Engineers was the systematic measurement of cyclic strains during complete alternating stress tests.

The machine used was designed by the author to make tests on specimens under repeated torsion or bending, or under repeated torsion and bending simultaneously. It is a slow-speed machine, the work done by its aid being at frequencies ether less than, or very slightly exceeding 200 cycles a minute. It appeared that the measurement of cyclic strains and conveniences in changing the frequency of the cycles without stopping and without alteration of stress would best be obtained by adopting a slow speed. The tests were made on solid and hollow cylindrical specimens of a dead mild steel.

Typical curves given in the paper showed how the cyclical range of strain varies with the range of stress and with the number of cycles endured. A fairly definite range of stress was always observed under which the elasticity became impaired. It was found that a large number of repetitions were endured at ranges of stress that indueed considerable ranges of extra-elastic strain. The curves suggest that a range of stress that would cause fracture in a very large number (say 100 millions) of cycles will be nearer in amount to the range that actually produced fracture (in one to five million cycles) than to the range of stress that brought departure from the elastic condition. In comparing the ranges of strain at which the various specimens cracked, the corresponding ranges of stress (calculated on the assumption of uniformly varying stress throughout the body of a specimen) were found to be greater for solid than for hollow testpieces.

The effect of rest appears to be similar to that of hardening after straining, and not to be of the nature of recovery of elasticity. Adjustment of elastic limits to range of stress was not observed in the experiments. Study of the effect of change of frequency of cycle upon range of extra-elastic strain appears to show that there is a marked variation of the physical state of the steel with frequency of cycle, the plastic "mobility" being greater with higher frequency.

The least range of induced maximum shear stress sufficient to impair elasticity was sensibly the same for both alternating torsion and alternating bending; thus Guest's criterion of elastic failure was fulfilled for the steel used.—*London Times Engineering Supplement.*

Substitute for Fodder.—Fodder is to be replaced in Germany by various substitutes, according to reports. There is a great annual production of straw, figuring about 45,000,000 tons annually, but its nutritive value is small. However a mixture of straw with alkaline salts and molasses is found very nutritious, and thus 100 lbs. of straw give 50 lbs. of cellulose whose nutritive value is 8 times as great. It is said that upwards of 100,000 tons of this mixture are already produced annually, and it is hoped to reach 500,000 tons before long.

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